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FOUNTAIN AT THE CITY WATER-WORKS PUMPING STATION, NEAR SAVANNAH, GEORGIA.

GEOLOGICAL SURVEY OF GEORGIA

S. W. McCALLIE, State Geologist

BULLETIN No. 15

A PRELIMINARY REPORT

ON THE

UNDERGROUND WATERS

OF

GEORGIA

BY

S. W. McCALLIE

State Geologist

**PREPARED IN CO-OPERATION WITH THE UNITED STATES
GEOLOGICAL SURVEY**

The Franklin-Turner Company, Atlanta, Ga.

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LETTER OF TRANSMITTAL

GEOLOGICAL SURVEY OF GEORGIA,

Atlanta, March 17, 1908.

*To His Excellency, HOKE SMITH, Governor, and President of the
Advisory Board of the Geological Survey of Georgia.*

SIR:— I have the honor to transmit herewith my report on the underground waters of Georgia, to be published as Bulletin No. 15 of this Survey. It will be noticed, in the prefatory note on another page, that this report was submitted for publication in 1905; but, owing to the strenuous duties and ill health of my predecessor, it has been delayed until the present. This delay, however, does not materially affect the usefulness of the report.

Very respectfully yours,

S. W. McCALLIE,
State Geologist.



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PREFATORY NOTE

In submitting this report, the writer wishes to state, that much of the data, here included, on the deep wells of South Georgia, is to be found in his "Preliminary Report on the Artesian-Well System of Georgia," published by the Geological Survey of Georgia in 1898. That part of the report, therefore, which pertains to these wells, may be considered an enlarged and revised edition of the report of 1898.

Furthermore, the writer wishes to here acknowledge his indebtedness to Dr. T. Wayland Vaughan and to Dr. W. H. Dall, of the United States Geological Survey, for the identification of fossils, and for valuable assistance rendered in working out the stratigraphy of the Coastal Plain. Like acknowledgment is also due Dr. R. M. Harper, who furnished important information concerning the distribution of the Altamaha grit and the Eocene limestones.

In addition to the assistance here credited, there will be found throughout the report various acknowledgments of aid rendered by well-contractors and others, who, in most cases, took especial pains to furnish the data desired.

In closing this prefatory note, the writer desires especially to express his gratitude to Mr. M. L. Fuller, chief of the Eastern Section, Division of Hydrology of the United States Geological Survey, for assistance and advice rendered in getting up this report.

Atlanta, Ga., February, 1905.



THE UNDERGROUND WATERS OF GEORGIA

CHAPTER I

INTRODUCTORY

The underground waters of a region, available to man, are derived directly or indirectly from the rainfall. Water, falling on the surface of the earth, whether in the form of rain, snow or hail, disappears by evaporation, is carried off by surface drainage, or is taken up by the porous soils. Only that part of the rainfall, absorbed by the soils, has any direct bearing upon the question of underground waters. The amount of rainfall, which may be great or small, taken up, depends upon the porosity of the soils, the surface inclination, the rate of precipitation, and the surface evaporation.

GENERAL CONDITIONS GOVERNING THE AMOUNT OF WATER TAKEN UP BY SOILS

POROSITY OF THE SOILS. — It is a well known fact, familiar to every observer, that sandy soils take up water much faster than clay soils. The clay soil may be able to retain a higher percentage of water than the sandy soil; nevertheless, the rate of absorption is always much faster in the former than in the latter. This fact is well illustrated by an examination of clay and sandy soils after the passing of a hard shower. In the one case, the surface will be found wet, and probably the small depressions still filled with water; while in the other, the surface of the soil may show but little evidence of a recent rainfall. The farmer is familiar with these different soil conditions, and he regulates the distribution and cultivation of his crops accordingly. Experience has taught him, that his fields, having sandy soils, can be cultivated at times, when it

would be ruinous to his crops to attempt to cultivate his fields having clay soils. He may not know, that a considerable portion of the rainfall, which is absorbed by the soils, is a perpetual source of supply to his spring; yet he is aware of the fact, that there is a marked difference in soils for taking up water.

The rainfall, when it comes in contact with the surface of the earth, is still impelled downward by gravity. The force, which retards this downward tendency of the rainfall in a soil, is the friction of the water against the sides of the soil pore spaces, through which it descends. When these pore spaces are large, as in sandy soils, friction is reduced; the rate of descent of the water is rapid; and, within a very short time, the water escapes beyond the effect of surface evaporation, and joins the permanent supply of underground water. On the other hand, where the soil pore spaces are small, as in clay soils, friction becomes much greater, and the water is retained for a longer time near the surface, thus permitting a correspondingly large proportion of the rainfall to be carried off by surface evaporation.

The law, governing the flow of water in soils of various degrees of porosity, has been quite extensively discussed by Prof. Chas. A. Slichter,¹ in his paper on the motion of underground waters. He finds, that, theoretically, water, when free to move in a vertical direction, as in the case of the rainfall being absorbed by a soil, has a velocity in medium fine sand nearly a hundred times as great as in silt or alluvial soils. In other words, a fine sand will take up, in a given time, much more rainfall than an alluvial soil. This being true, it is evident, that the supply of underground waters of any region must bear a very close relation to the porosity of the soils and the underlying rocks. This relation of porosity to the amount of supply of underground water is well illustrated in the case of common shallow wells. In a district, where the clays are of a sandy nature, such wells, other things being equal, always furnish a more copious supply of water than wells in more compact clays.

¹ Water Supply Paper No. 67, U. S. Geol. Surv., 1902.

EFFECT OF SURFACE INCLINATION. — The effect of the inclination of the surface upon the amount of rainfall taken up by a soil, is a very important factor to be considered in the discussion of underground waters. The amount of rainfall, absorbed by a soil, depends upon the length of time the water is in contact with the surface. When the surface is inclined, as in a hilly region, the water escapes by surface drainage, before the pores of the soil can take it up; but, on the other hand, when the surface is level, and there is but little or no surface-flowage, a high percentage of the rainfall will be absorbed by a soil. This accounts, in a large measure, for the streams in a mountainous district becoming much more swollen after a hard rain than the streams of a more level region. The water, in the one case, owing to the inclination of the surface, escapes by surface-drainage; and, in the other, it is largely taken up by the soil, to become a part of the underground water-supply. The farmer terraces his field, primarily, to keep it from washing; but, at the same time, he increases the absorption of water by his soils, by decreasing the general surface inclination. He thus turns a destructive agent into a constructive one, by retarding the surface flow of the rainfall, until it can be taken up by the soils.

RATE OF PRECIPITATION. — The rate of the rainfall regulates, to a greater or less extent, the amount of precipitation taken up by a soil. If the rate of precipitation is quite slow, almost any soil, however fine grained, will take up a high percentage of rainfall. Yet, when the rain descends in hard showers, even the most open sandy soils may take up only a small proportion of the total precipitation. Heavy showers overgorge the soil pores, and much of the rainfall escapes in rills, to swell the streams, before it can be taken up. Here, as in the case of soils having a highly inclined surface, the water does not remain sufficiently long in contact with the surface to be absorbed. As a general rule, the minimum amount of rainfall is always taken up by the soils during heavy showers; and the maximum amount escapes by surface drainage. Each variety of soil has a definite rate of absorbing water, depending, as above stated, upon the size of the pore space. When the maximum rate of absorption is reached, the surplus rainfall must escape by surface drainage or evaporation.

SURFACE EVAPORATION. — A considerable proportion of the total precipitation of any region is taken up by surface evaporation, before it has had time to be absorbed by the soils. It has been shown by Newell,¹ that from one-fourth to one-half of the total rainfall of the Southern States is carried off by streams. This would leave one-half to three-fourths to escape by surface evaporation. Evaporation, as here used, includes not only the amount of precipitation evaporated from the soils, but also that, evaporated from the surface of the streams and taken up by vegetation. It is not known, what proportion of evaporation takes place directly from the surface of the soils; however, it must be relatively large, owing to the comparative areas of the streams and land surfaces.

There are several conditions, which modify the rate of surface evaporation, the most important of which are temperature, rate of the wind's motion, and the absence or the presence of vegetation. The capacity of the air, for taking up moisture, depends upon its temperature. Hot winds will take up a much larger proportion than cold winds. The rate of evaporation is, therefore, much greater, in the temperate zones, in summer than in winter. Surface evaporation is also accelerated or retarded by the motion of the air. When there is little or no wind, the air, in contact with the soil, becomes saturated with moisture, and evaporation can only take place by diffusion through the air. A strong wind is continuously changing the air in contact with the soils, and hence accelerates the process of evaporation. Vegetation retards evaporation by decreasing the effect of the sun's rays upon the surface; and, at the same time, it interferes with the free circulation of the air. Other things being equal, a forest-covered area will, therefore, be more abundantly supplied with underground water, than a region destitute of vegetation.

DISTRIBUTION OF THE RAINFALL, ABSORBED BY THE SOILS

A part of the rainfall, taken up by the soils, is again returned to the atmosphere by evaporation; a part reaches the underground water, and forms a perpetual supply for wells and springs; and a part

¹ U. S. Geol. Survey, Nineteenth Annual Report, 1897-'98, p. 94.

is taken up in the weathering of the rocks. The relative proportion, which these different parts of the rainfall, absorbed by the soils, bear to each other, is quite variable, depending on atmospheric conditions and the physical structure of the soils. King,¹ in discussing the percentage of precipitation, which penetrates the soil, says, that it may be laid down as a broad proposition, that nearly all the water of the rivers and small lakes is that which has seeped through the soils. He further states, that in the more level portions of the United States, this run-off amounts to from one-fifth to one-half of the entire precipitation. According to these statements, that part of the rainfall, absorbed by the soils, which reaches the underground waters, varies from 20 to 50 per cent. of the total precipitation.

The water, taken up by the soil and having escaped beyond the influence of surface evaporation, becomes a part of the permanent water-supply. It, here, below what is known as the permanent water-level, occupies the interstices of porous rocks, like sandstone, and fills fissures and crevices, which have been formed by the folding of the strata, or from other causes. The total amount of underground water, within the crust of the earth, has been estimated by Prof. Slichter² to be sufficient to cover the entire surface of the earth, to a uniform depth of more than 3,000 feet. This enormous amount of water is held in the pore spaces of the rock, like water in a sponge. Some rocks, such, for instance, as sandstone, will absorb more than 25 per cent. of their own weight in water. Such rocks, when pierced by the drill, have the power of giving up a large supply of water, and are, therefore, known as *water-bearing*, or *permeable rocks*; while those, which furnish but little or no water, are designated as *impermeable rocks*.

The permeable rocks, or the main underground water carriers, are such clastics as the conglomerates, the sandstones, and the more porous limestones; and the impermeable rocks are the clays, the marls, the shales and the slates. These rocks usually form successive layers, one imposed upon the other, like the coating of an onion. It

¹ U. S. Geol. Surv., 19th Ann. Rept., 1897-'98, p. 95.

² Water-Supply Paper No. 67, U. S. Geol. Surv., 1902, p. 15.

rarely happens, that the layers are perfectly horizontal. They usually slope, at greater or less angles, so that rocks, which, at one point, outcrop on the surface, may, at another point, probably only a few miles away, lie hundreds of feet below the surface. The rainfall, which is taken up by the soils, enters these porous rocks at their outcropping. When they are overlain and also underlain by impervious clays and shales, the water, which they have taken up from the surface, can only find its way to the surface again through breaks in the overlying strata. If this continuity is broken by fissures, or by the wearing away of the overlying rocks by erosion, the water escapes to the surface, in springs or by seepage; but, if the impervious stratum is pierced by the drill, the water may escape as a flowing well.

In addition to that part of the underground water, which reaches the surface as springs and flowing wells, there is also a limited amount of underground water, which reaches the surface through shallow wells. The amount of underground water, which reaches the surface through shallow wells, is comparatively small; nevertheless, this source of water-supply is of very great importance. The water, which supplies this class of wells, usually lies within 75 feet or less of the surface, and is generally reached, with but little expense, by means of the pick and shovel. The water of these wells is obtained from the uppermost part of the available underground water-supply; and they, therefore, rarely extend over a few feet below what is known as the water-table, a plain, below which the soil is always saturated.

CHAPTER II

PHYSIOGRAPHIC FEATURES OF GEORGIA

Physiographically considered, the State of Georgia is divided into five well marked sub-divisions; namely, the Coastal Plain, the Piedmont Plateau, the Appalachian Mountains, the Appalachian Valley and the Cumberland Plateau. Each of these sub-divisions is comparatively well defined; nevertheless, in some instances, the line of separation can not always be sharply drawn. Often, in places, one sub-division blends with another, so that it is frequently impossible to give any definite boundaries. In such cases, the boundaries of the sub-divisions can only be spoken of, as occurring within certain limits.

The physiographic sub-divisions of the State, above enumerated, are not peculiar to Georgia alone. They form a part of the main topographic provinces of the Eastern division of the United States, which have been described under the names here given, by Hayes¹ and others. As a whole, these subdivisions may be spoken of as certain well marked land forms, composing belts or zones of variable width extending from New York to Alabama. Each sub-division has its own topographic peculiarities and constitutes a distinct physiographic type. They all have a southwesterly trend, and traverse the various States between the limits just given. The surface configuration of Georgia, as represented by the physiographic sub-divisions above enumerated, are here described in detail.

THE COASTAL PLAIN. — The Coastal Plain comprises all that part of Georgia lying south of an irregular line, known as the fall-line, connecting the cities of Augusta, Milledgeville, Macon and Columbus. The area here included embraces more than half of the entire State. Generally speaking, this sub-division of the State may

¹ U. S. Geol. Survey, Nineteenth Ann. Rept., 1897-'98, pp. 9-58.

be spoken of as a nearly level plain, having a gentle slope to the southward. The maximum elevation of the plain occurs along the fall-line, where, in places, it reaches a height of more than 600 feet above sea-level.

The surface configurations of this area are those, common to lands which have recently emerged from the sea. To the northward, there are slight elevations and depressions, conforming in direction to the course of the rivers. As the fall-line is approached, these surface irregularities become more pronounced; while, to the southward, they gradually decrease in prominence, until they are finally lost in an almost featureless, sandy, pine-clad plain.

Besides the general surface irregularities, here referred to, there are also minor irregularities, which have resulted from local erosion. These surface irregularities, which are most frequently met with, in the vicinity of the larger streams, give to the Coastal Plain, in certain sections, an appearance, not unlike the more hilly portions of the northern part of the State. Topography of this kind may be seen in Decatur, Thomas and other counties in the western part of the Coastal Plain, as well as in some of the counties lying along the fall-line.

The streams of the Coastal Plain are numerous, and are usually sluggish. Those rising north of the fall-line are navigable the greater part of the year, for steamboats of considerable size. The larger streams occasionally have, on either side, high bluffs; but, oftener, they traverse low palmetto swamps, or lands having the appearance of a partially filled river-valley, cut by the stream, when the land stood at a higher level. The rivers which flow into the Atlantic enter it by bays or sounds, protected seaward by a chain of low wave-built islands. The land near the coast is low, flat and poorly drained, presenting quite a contrast with parts of the Coastal Plain, at places near the fall-line.

THE PIEDMONT PLATEAU. — The Piedmont Plateau is a wide belt, or zone, of elevated land, stretching from the foot of the Appalachian Mountains to the Coastal Plain. Its northern limit is an ill-defined line, extending from the extreme northeastern corner of the State to the Georgia-Alabama line, a few miles southwest



GULLIES AT ANDERSONVILLE, SUMTER COUNTY, GEORGIA, IN THE LAFAYETTE SANDY CLAYS, SHOWING HOW SMALL SPRINGS MAY ORIGINATE.



of Cedartown. It traverses the State from the northeast to the southwest, with an average width of more than 100 miles, and comprises an area of something like one-third of the total area of the State. This physiographic sub-division consists of an old land form, which has been reduced by erosion to a pene-plain. Along its northern boundary, it has an average elevation of about 1,200 feet above sea-level; while, at its junction with the Coastal Plain, it is reduced to a little less than half of this elevation. It has, therefore, a slope to the southward of about 5 feet per mile, or about twice the slope of the Coastal Plain.

The Piedmont Plateau, when viewed from an elevated point, has the appearance of a level plain, dotted here and there with isolated mountains and hills, such as Stone Mountain, Kennesaw Mountain and Pine Mountain, which rise from 500 to 800 feet above the general level of the Plateau, and which appear to be remnants of an older and somewhat different topography.

The minor inequalities of the surface of the Piedmont Plateau are entirely overlooked, or minimized, by a view from an elevated point. The region, instead of being a level plain, has a broken surface, made up of low, well-rounded hills and ridges, separated by narrow fertile valleys. These minor hills or ridges, which usually have a southwesterly trend, have an elevation varying from 200 to 300 feet above the stream-level.

The streams of the Piedmont Plateau are usually rapid, and are frequently marked by cataracts and water-falls. This feature of the streams is especially accentuated along the margin of the Coastal Plain. The river valleys, which are being continually increased in depth by the erosive action of the streams, rarely ever exceed a width of more than a few hundred yards.

THE APPALACHIAN MOUNTAINS. — This physiographic sub-division is located in the northern part of the State, along the Georgia-Tennessee line, and extends as far south as Cartersville, the county-site of Bartow county. It has a somewhat triangular form, being limited on the south by the Piedmont Plateau, and on the west by the Appalachian Valley. The western boundary may be said to correspond with what is known as the Cartersville Fault, a

great displacement marking the boundary between the metamorphic and the sedimentary rocks in the northwestern part of the State. This division embraces all, or a part of the following counties:—Rabun, Towns, Lumpkin, Union, Fannin, Gilmer, Pickens and Bartow. It is one of the smallest of the five topographic sub-divisions of the State; nevertheless, it comprises an area of more than 2,000 square miles.

This sub-division forms the southern terminus of the Appalachian Mountains. It is preëminently a mountain region, noted for its picturesque scenery and lofty mountains. The average elevation of the region is less than 2,000 feet; yet, there are numerous mountains within the area, attaining an altitude of more than twice this height. The larger mountains occur in groups or masses without definite arrangement. The higher peaks of these groups usually have precipitous slopes, which, in places, become almost inaccessible. The lesser mountains, and the ridges of the region generally, have a southwesterly trend, corresponding to the general course of the streams. The valleys are narrow, and are traversed by rapid streams, which, in places, form falls many feet in height. Between the main mountains and the ridges, there is a large area of broken country, with hills rising 400 or 500 feet above the general stream-level. This portion of the sub-division resembles very closely the more hilly parts of the Piedmont Plateau.

THE APPALACHIAN VALLEY.—The Appalachian Valley may be defined as a low land, lying between the Appalachian Mountains and the Cumberland Plateau. This physiographic sub-division, which traverses the northeastern corner of the State in a southwesterly direction, is about 35 miles wide; and it has an average elevation of about 850 feet above sea-level. Its western boundary is an irregular line, following the eastern escarpments of Pigeon and Lookout mountains.

The region is made up of a number of minor valleys, separated from each other by sharp or by well-rounded ridges. The former ridges, as in the case of Taylor's Ridge and Chattoogata Mountain, often attain an altitude of 1,500 feet; while the latter rarely reaches a height of more than 1,200 feet. These ridges all have a northeast-

southwest trend, and give to the region a corrugated appearance. The minor valleys are usually narrow, and are traversed by rather sluggish streams which in the northwestern part of the area flow north into the Tennessee River; while those in the other parts of the area flow southward to the Gulf of Mexico.

THE CUMBERLAND PLATEAU. — The Cumberland Plateau occupies the extreme northwestern corner of Georgia, and embraces Pigeon Mountain and portions of Lookout and Sand mountains. This subdivision of the State constitutes the extreme eastern margin of the Cumberland Highlands, traversing Alabama and Tennessee further to the westward. Broadly speaking, the area is an elevated tableland, bisected longitudinally by a deep, narrow valley. That part of the area lying east of the valley constitutes Lookout and Pigeon mountains, and that, to the west, Sand Mountain. These mountains have broad, flat tops, with an average elevation of about 1,800 feet above sea-level. The slopes of the mountains are always precipitous, and are often marked by bold sandstone cliffs, which, in some places, attain a height of 200 feet.

Lookout Mountain, as it enters Georgia from Alabama, forms a broad, flat-top mountain, about 10 miles in width. Some six or eight miles north of the State-line, the mountain sends off to the northward a spur, known as Pigeon Mountain. From this point to its northern terminus in the vicinity of Chattanooga, it varies in width from two to four miles. Some of the small streams, which take their rise on Lookout, in their descent to the valley below have cut deep and precipitous chasms in the sandstone bluffs which form the brow of the mountain. Sand Mountain, as represented in Georgia, differs from Lookout Mountain, mainly, in being broader, and in having a more even surface. The valley, above referred to as bisecting the Cumberland Plateau region of Georgia, is the only valley occurring in the physiographic sub-division. It has an average width of about three miles, and is traversed by Lookout Creek, a sluggish stream, of considerable size, flowing north into the Tennessee River. The surface of the valley is rolling, but, at the same time, it has a general slope to the northward.

CHAPTER III

GEOLOGY

Each of the great time divisions of geological history has representatives in the rocks of Georgia. The southern portion of the State, described under Physiographic Features of the State, as the Coastal Plain, is made up of rocks ranging in age from the Cretaceous to the most recent. To the north of this area, comprising both the Piedmont Plateau and the Appalachian Mountain regions, occur the Metamorphic, or the Crystalline rocks. Still further to the north and west, forming the Appalachian Valley and the Cumberland Plateau, are the unaltered Paleozoics. The line of demarkation, between these three major geologic divisions of the State, is not always sharply drawn. This is especially true of the second and third divisions, where the Crystalline and the unaltered Paleozoic rocks grade into each other, without any sudden or abrupt change. The line, separating the first division, or the recent clastics, from the Crystalline, on the other hand, is more distinct, being marked not only by a very striking unconformity, but also by great change in the lithological character of the rocks.

The sub-divisions of the rocks of the Coastal Plain, in descending order, are given in the following table: —

- 1 Pleistocene
Columbia Sands
- 2 Pliocene
LaFayette
- 3 Miocene
Altamaha Grit ¹
Chattahoochee

¹ Recent study of the Altamaha grit seems to indicate that it is probably a phase of the Lafayette and is therefore Pliocene.

- 4 Eocene
 - Vicksburg-Jackson
 - Claiborne
 - Midway-Sabine
- 5 Cretaceous
 - Ripley
 - Eutaw
 - Tuscaloosa or Potomac

PLEISTOCENE

COLUMBIA. — The Pleistocene rocks of Georgia are mainly represented by the Columbia sands, a superficial deposit covering the greater part of the Coastal Plain. The formation consists chiefly of white and yellow sands, rarely showing any distinct lines of stratification. In places, it contains water-worn pebbles, a quarter of an inch or more in diameter; but generally it consists of fine-grained sand or loam, which, in the vicinity of the rivers or the coast, may pass into silts.

The Columbia sands sometimes form hills rising 30 feet or more above the general level of the surrounding country. These hills, which are often spoken of as the "Sand Hills," are irregularly distributed throughout the Coastal Plain, from the fall-line to within a few miles of the Atlantic coast. In certain limited areas, known as the "Red Hills," the Columbia sands are entirely absent, a condition due either to the sands not having been originally deposited, or to their subsequent removal by erosion. The thickness of the formation in Georgia may be said to vary from a maximum of 40 feet to a few inches. Throughout the Piney-woods region, where the surface is practically level, the average thickness probably does not exceed two feet.

McGee, in his description of the Columbia formation in the southwestern part of the State, says: "The rivers are flanked by belts of loam with basal pebble beds more or less closely approaching the fluvial deposit of the type locality. Here, as in the north, the loam is more homogeneous and more closely similar not only in its different parts on the same river but among the various rivers than the phase developed on the divides."

In general, he finds the deposits of Georgia, quite similar to the deposits along the Coastal Plain further north, with, however, one essential difference. In the north, he notes, that what he terms the fluvial phase of the deposit rises only to the level of the interfluvial, or the deposits between the streams; whereas, in Georgia, the fluvial deposits rise far above the interfluvial deposits.¹

PLEOCENE

LAFAYETTE. — The Lafayette, whose exact position in the geologic time scale is still debated, like the Columbia formation, is a superficial deposit, covering most of the Coastal Plain. The formation consists of orange and vari-colored clays and sands, with local beds of gravel. The basal member of the formation along the fall-line frequently becomes distinctly pebbly. These water-worn pebbles, which consist largely of quartz derived from the crystalline rocks to the north, occur irregularly distributed throughout the vari-colored sandy clays, but more often they are found in layers or pockets. They also occur in the basal member, at places, with fragments of white clay forming more or less continuous layers. These phases of the lower division of the formation become less pronounced in the southern part of the State, where sandy loam and vari-colored stratified clays predominate.

The upper member of the formation differs from the lower, in being more uniform, both in physical structure and lithological character. Along the fall-line, at some points, it becomes quite pebbly; however, as a general rule, it is made up almost entirely of massive reddish or motley sandy clays. Frequently, the massive clays of the upper division are hardened into a compact mass, having almost the consistency of sandstone. This indurated layer resists the erosive action of surface-waters; and, by being undermined by the washing away of the layers below, it often stands out in high, perpendicular walls. Excellent illustrations of this mode of erosion are frequently met with, in the vicinity of streams, which have lowered their channels into the underlying formations.

The thickness of the Lafayette formation is quite variable. At some places, near the northern margin, where it has been protected by the Columbia sands, it attains a maximum thickness of more

¹ U. S. Geol. Survey, Twelfth Ann. Rept. 1890-'91, p. 389.

than 80 feet; at other points, it has been entirely removed by erosion. These eroded areas are quite irregular in outline, and may occur at any point throughout the Coastal Plain. They are more frequently met with, however, in the vicinity of the larger streams; yet, they are not entirely absent from the level piney-woods.

The marine Pliocene, according to Loughbridge,¹ occupies a narrow strip of the coast extending from Savannah to St. Mary's. The western boundary of the formation appears never to have been accurately traced. However, it is supposed to be an irregular line corresponding with what Loughbridge calls the second terrace, 20 miles or more inland. Deposits, assigned to this formation, have been found as far inland as the western part of Chatham county; near Jesup in Wayne county; and at Burnt Fort in Camden county. The formation is also supposed to underlie Okefenokee Swamp, and to extend as far west, along the Georgia-Florida line as the Suwanee River.² The lithological character of the formation is varied. It consists mainly of unconsolidated sands, clays and marls. No data are at hand, by which to estimate the thickness of the formation. All of the deep wells along the coast, south of the Savannah River, penetrate the Pliocene beds; but, in only a few cases, have complete samples of the borings been preserved. These samples usually contain but few organic remains, so that it is often practically impossible to determine from them anything definite, as to the exact depth to which the beds extend.

MIOCENE.

The Miocene rocks of Georgia include several subdivisions, the most important of which are the Altamaha grit and the Chattahoochee formation.

THE ALTAMAHA GRIT, which is probably the eastern extension of the Grand Gulf of Mississippi and Alabama, covers a much larger area than any of the other subdivisions of the Post-Eocene. Its northwestern limit coincides with the eastern boundary of the Vicksburg-Jackson, except in Washington and Jefferson counties, where it comes in contact with the Claiborne. It forms a belt, with a maxi-

¹ U. S. Geol. Surv., Bull. No. 84, p. 84.

² Recent study seems to indicate that the marine Pliocene is confined to a narrow strip along the Atlantic Coast and does not include or extend as far west as the Okefenokee Swamp.

num width of more than 75 miles, and appears to reach its greatest development along the Oconee River in Laurens and Montgomery counties, where it attains a thickness of more than 200 feet.

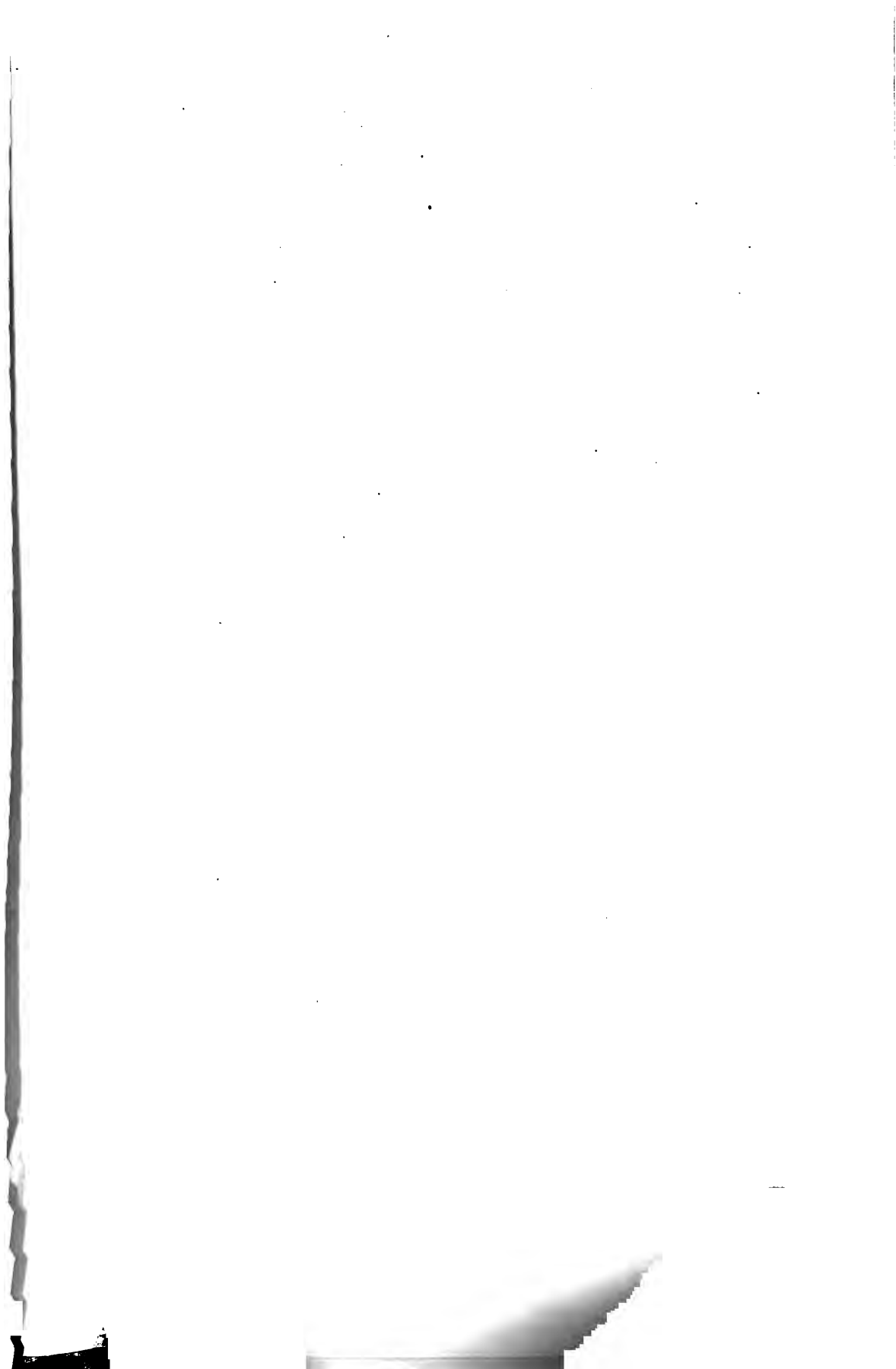
The Altamaha grit, as the name suggests, is made up largely of heavy-bedded, indurated sands, with a clay and silica matrix. The particles of sand forming the grit are usually sharp; but, in the same beds, the sharp sand has intermingled with it water-worn pebbles, some of which attain an inch or more in diameter. The lower beds of the formation consist chiefly of clay, which, near the contact of the underlying limestones often become calcareous. Owing to the absence of fossils in the Altamaha grit, its exact position in the geologic time-scale has never been definitely determined. It has been placed by Dall as early Miocene; while Dr. Eugene A. Smith, State Geologist of Alabama, who thinks it is the eastern extension of the Grand Gulf of Mississippi and Alabama, is of the opinion that it is much more recent, probably Pliocene, or even as late as the early Pleistocene.

THE CHATTAHOOCHEE FORMATION, whose limits, so far, have not been defined, seems to be best developed along the Georgia-Florida line in Decatur, Grady and Thomas counties, where it has been examined by Langdon, Vaughan and others. The rocks of this formation, at the railroad bridge over the Chattahoochee River at the New Chattahoochee landing, the type locality, consist of argillaceous and sandy limestone alternating with beds of purer character. In addition to the sub-division of the Miocene, above given, there is still another, known as the Jacksonboro limestone.¹ This subdivision, which has been studied by Lyell, Clarke and Vaughan, appears to be well developed in Screven county, near the confluence of Brier and Beaver Dam creeks. The extent of the formation is unknown; but it is probably confined chiefly to Screven and the adjacent counties.

EOCENE

The Eocene rocks of Georgia may be divided into three subdivisions; viz., the *Vicksburg-Jackson limestone*, the *Claiborne* and the *Midway-Sabine*.

¹ The recent studies of Dr. T. Wayland Vaughan show this to be approximately the Tampa horizon.





THE VICKSBURG-JACKSON LIMESTONE. — This sub-division of the Eocene rocks is well developed in Georgia. With the exception of a small break, of only a few miles, in Washington and Jefferson counties, this limestone forms a continuous belt from the Chattahoochee River, south of Fort Gaines, to the Savannah River, 30 miles south of Augusta. This belt is quite variable in width, due chiefly to the overlapping of the Altamaha grit, which forms its southern boundary. In Dougherty, Terrell and Randolph counties, it attains a width of more than 60 miles. It also reaches a like width along the Ocmulgee River, where the overlying Altamaha grit has been removed by erosion. Besides the main body, or belt, of the Vicksburg-Jackson limestone, here noted, there are also isolated exposures along the streams in Thomas and Brooks counties, near the Georgia-Florida line, and in Crawford county, near the contact of the Crystalline and Cretaceous rocks. The last exposure is interesting, as it shows that the Eocene sea, in which the Vicksburg-Jackson limestone was laid down, extended as far north as the Crystalline rocks. This northern extension of the formation also explains the absence of surface-exposures of the Claiborne, west of the Ocmulgee River.

The Vicksburg-Jackson limestone, as the name suggests, consists chiefly of limestone. It has a maximum thickness of more than 400 feet. The upper member of the formation is made up of hard and soft limestone, with more or less silica, in the form of cherty concretions, which are usually highly fossiliferous. The lower member contains more clay and sand, often in the form of comminuted shells, fragments of corals, and bryozoans, and the disk-like tests of foraminifera. The whole formation, throughout, is highly fossiliferous; and it is noted for its numerous limesinks and underground-streams.

THE CLAIBORNE. — The second subdivision of the Eocene rocks, which includes the Buhrstone series, occurs along the Chattahoochee River south of Fort Gaines, and also, according to Spencer,¹ along the Flint River south of Montezuma; but it reaches its greatest development between the Ocmulgee and Savannah rivers, where it

¹ Geol. Surv. of Georgia, First Report of Progress, 1890-'91, p. 51.

forms a belt, from 10 to 30 miles in width. This part of the formation, which consists of clays, sands and marls, often indurated and occasionally highly fossiliferous, overlaps, in places, the Cretaceous beds, and comes in immediate contact with the Crystalline rocks. One of these overlaps occurs at Robert's station, a few miles east of Macon, and another, in the vicinity of Grovetown, 17 miles west of Augusta.

The most marked lithological characteristics of the Claiborne, east of the Ocmulgee River, are the heavy beds of sands. These sands, which are usually stained with iron oxide are frequently indurated, and form, in places, beds of ferruginous sandstone several feet in thickness. An excellent exposure of these sandstones, containing a large number of silicified shells, is to be seen along the Central of Georgia Railroad, near Hollywood station, about ten miles south of Augusta, and at Wren's mill in the northern part of Jefferson county. Other Claiborne rocks, of special interest on account of their containing beautifully preserved fossils, are the heavy-bedded silicified limestone capping Brown's Mountain in Twiggs county, ten miles southeast of Macon. These rocks are also well exposed in a deep ravine, two miles south of Griswoldville. Further to the south and west, they appear to pass into marls or impure limestones.

The Claiborne clays are usually laminated and porous, partaking of the nature of fuller's earth. Some of the beds are quite fossiliferous, the most abundant fossils being impressions of leaves. Occasionally, beds of these clays are highly lignitic; but such clays are mostly locally developed, and rarely form beds of more than a few feet in thickness. The Claiborne, along the Chattahoochee River, is placed by Langdon at 232 feet, which is probably much less than the maximum thickness attained at points east of the Ocmulgee River.

MIDWAY-SABINE. — This formation, which includes all of the rocks between the Claiborne and the Cretaceous, corresponds to what is often designated as the lower member of the Eocene. It is confined to a narrow belt extending from a point in Macon county east of the Flint River, near Montezuma, to the Chattahoochee River

in the vicinity of Fort Gaines. This belt has an average width of about seven miles; but, along the Chattahoochee River, it attains a width of more than twice this distance. Its northern and southern boundaries are usually quite sinuous, owing to the irregular surface erosion and to the overlapping of the Vicksburg-Jackson limestone. The Midway-Sabine rocks consist of impure limestone, clays and sands. These sands are often glauconitic; and, in places, they become cemented by iron oxide into ferruginous sandstones. These sandstones, which frequently contain well preserved casts of gastropods, are well developed near the base of the formation. Some of the best exposures of these ferruginated fossiliferous sandstones occur on the Carter plantation, near Quebec, in the southeast corner of Schley county, and in Stewart county, about six miles northeast of Lumpkin. The clays are usually sandy; but they frequently contain much lime, thus passing into marls. Many of the beds are lignitic, and occasionally contain well preserved plant remains. The limestones are argillaceous, and often highly fossiliferous. In some places in the northern part of Randolph county, these limestones become cavernous, and are traversed by subterranean streams.

The Midway-Sabine rocks are best developed along the Chattahoochee River, where, according to Spencer,¹ they attain a thickness of about 600 feet. East of the Chattahoochee, they appear to decrease in thickness going eastward, and finally disappear, or are buried beneath the Vicksburg-Jackson east of the Flint River.

THE CRETACEOUS

The Cretaceous rocks of Georgia form the northern margin of the Coastal Plain, where they constitute a belt of variable width extending from the Chattahoochee to the Savannah river. The maximum width of the belt, which occurs along the Chattahoochee, is about 50 miles. Between the Chattahoochee and the Ocmulgee rivers, the width does not average more than 20 miles; while, east of the Ocmulgee, the width is reduced to less than ten miles.

Langdon, Smith and others recognize three horizons in the Cre-

¹ Geol. Surv. of Ga.; Report of Progress, 1890-'91, p. 42.

taceous rocks along the Chattahoochee River, viz., the Ripley, the Eutaw and the Tuscaloosa or Potomac.

THE RIPLEY. — The Ripley, which seems to be confined entirely to that part of the Cretaceous belt between the Chattahoochee and the Ocmulgee rivers, consists of a great thickness of sand, clay and marl, with a few thin beds of soft, impure fossiliferous limestone. The sands often show cross-beddings, and contain more or less glauconite. They are generally incoherent, and are readily washed into deep gullies by surface waters. The clays are mostly impure kaolins, varying from yellow and gray to almost black. The darker clays are often highly lignitic, and contain more or less pyrite, frequently in the form of nodular concretions. The marls are mostly of a dark-gray or greenish color. They often become indurated, forming conspicuous projecting ledges along the banks of the streams. Some of the marl-beds are made up largely of shells, often beautifully preserved. Shark's teeth, fragments of bones and coprolites are also common in the marl-beds.

THE EUTAW AND THE TUSCALOOSA OR POTOMAC. — These two formations differ from the Ripley, mainly in the less frequent occurrence of limestone and marls. They consist chiefly of sands with more or less clay. The clays, which seem to be best developed in the lower division, are well exposed in Taylor county, and also at numerous points between Macon and Augusta. These clays are usually quite pure kaolin, well suited to the manufacture of crockery. They occur as locally developed beds associated with cross-bedded sands. Neither of these clays¹ or sands are fossil-bearing, east of the Ocmulgee River; and, as a consequence, that part of the Cretaceous was mapped solely on its lithological characteristics. It is quite probable, that a part, or possibly all, of these sands and clays, mapped by the writer as Cretaceous east of Macon, may prove, upon further study, to be Claiborne.²

THE CARBONIFEROUS

The Carboniferous rocks reach their greatest development on the

¹ Since the above was written fossil leaves have been found by the writer in the clay pit at Carr's Station in Hancock County.

² For a list of fossils of the Cretaceous and the Tertiary formations see chapter XI.

Cumberland Plateau. They occur also in the Appalachian Valley region, but only as the lowest members of the series. This system of rocks is calcareous below and siliceous above. The calcareous rocks consist of *Fort Payne chert*, the *Bangor limestone* and the *Floyd shale*. The first two members of this division are made up mainly of limestone; but the Fort Payne chert contains also a large amount of siliceous material in the form of chert. The Floyd shale is usually quite calcareous; and, in places, it passes into thin-bedded limestones. The aggregate thickness of the calcareous member of the Carboniferous rocks is more than 2,000 feet.

The upper member of the Carboniferous rocks, which are confined almost entirely to Sand, Pigeon and Lookout mountains, consists of conglomerates, sandstones and shales, with a number of workable seams of coal. This member of the Carboniferous is divided into two divisions; viz., the *Lookout sandstone* and the *Walden sandstone*. The Lookout sandstone has a thickness of about 500 feet, and is made up of conglomerates, sandstones, and thin-bedded shales and coal. The Walden sandstone is similar to the Lookout sandstone; but it attains a thickness of nearly 1,000 feet. The upper member of the Carboniferous rocks, or what is generally designated as the Coal Measures, differs from the other divisions of the Paleozoic rocks in being almost horizontal.

THE DEVONIAN

This system of the Paleozoic rocks is poorly represented in Georgia. Until recently, the only rocks assigned to the Devonian series in the State was a thin stratum of black shale, with a maximum thickness of only about 40 feet. Hayes recently noted, in the Rome folio of the United States Geological Survey, the occurrence of other rocks which he classifies as Devonian. These recently discovered Devonians occur at various points northwest of Rome. They consist of shale and sandstones, of limited thickness, and are apparently of local distribution.

THE SILURIAN

The Silurian rocks are highly calcareous. With the exception of the uppermost member of the system, they consist almost entirely

of limestones. The rocks of this division of the Paleozoic are divided into three series; viz., the Knox dolomite, the Chickamauga limestone, and the Rockwood formation.

The Knox dolomite, the oldest of the series, is a cherty, heavy-bedded magnesian limestone, having a maximum thickness of about 5,000 feet. The series forms broad, flat chert ridges, traversing the Appalachian Valley in a northeasterly-southwesterly direction.

The Chickamauga limestone, the other Calcereous member of the Silurian series, is made up of blue and mottled limestones. In places, some of these beds become shaley; but they always carry a high percentage of lime; and, as a consequence, they are readily soluble by atmospheric waters. The Chickamauga limestone varies from 600 to 1,800 feet in thickness, and is the main valley-forming rock of the Silurian system.

The uppermost member of the Silurian rocks, *the Rockwood formation*, consists of sandstones and shales. These sandstones frequently become heavy-bedded, and form sharp-crested ridges, of considerable eminence. The thickness of the formation varies from 600 to 1,500 feet, the maximum thickness being attained in Chattooga Mountain, a very prominent ridge in the northern-central half of the Appalachian Valley region.

THE CAMBRIAN

The Cambrian rocks are best developed along the eastern side of the Appalachian Valley. They consist of quartzites, shales and limestones. The quartzites are often heavy-bedded, and give rise to some very conspicuous ridges. Mountains and ridges of these quartzites are to be seen in the vicinity of Cartersville, and also along the Georgia-Alabama line west of Etna. The shales are usually calcareous; but, locally, they become siliceous or sandy. They attain a great thickness, and are always valley-forming. Intercalated with the shales, and often forming strata many feet in thickness, occur also beds of blue siliceous limestones. The Cambrian rocks of Georgia all have the appearance of having been deposited in muddy seas near the shore.

THE CRYSTALLINE

The Crystalline rocks of Georgia form a belt, more than 100 miles in width, traversing the northwestern part of the State in a southwesterly direction. They constitute both the Piedmont Plateau and the Appalachian Mountain physiographic sub-divisions. These rocks were formerly regarded as pre-Cambrian; but more recent study seems to indicate, that they vary in age from Archean to Carboniferous. Van Hise, in speaking of the age of the rocks, says: "In our present very imperfect state of knowledge, to call the whole Algonkian or Archean, or even pre-Cambrian, is wholly unwarranted."

These rocks are wholly or partially crystalline. The former includes the granites, the gneisses, the schists, the diorites and the diabases; and the latter, the limestones, the quartzites and the conglomerates. The partially crystalline rocks are found in greatest abundance along the eastern margin of the area; but they also occur as far to the east as the quartzite ridges of Meriwether, McDuffie and Lincoln counties, those occurring in Meriwether county are known as Pine Mountain, and those in McDuffie and Lincoln counties as Graves Mountain. The most abundant rocks are the gneisses and schists. Intimately associated with and often cutting these rocks as dikes, occur the granites and diabases. The granites vary in texture from coarse-grained pegmatite to fine-grained monumental stone. They frequently cover areas of considerable extent, and occasionally form mountains or hills; as, for instance, Stone Mountain, which rises 686 feet above the general level of the surrounding country. These acid intrusives seem to be of different ages; however, they all appear to be much older than the diabases, which always occur in the form of dikes. One of the most persistent and constant characteristics of the rocks of the Crystalline area is their schistose structure. With the exception of the granites, and the diabases, this physical structure is common to nearly all the rocks of the area. In addition to the schistose structure, the rocks are usually much folded and contorted, showing every evidence of having been subjected to intense dynamic force. The trend of the rocks throughout the region is to the southwest, while the prevailing dip is to the southeast.

CHAPTER IV

GENERAL NOTES ON THE UNDERGROUND WATERS OF THE SEVERAL GEOLOGICAL FORMATIONS OF THE STATE

THE COLUMBIA. — The Columbia sand, by reason of its loose texture takes up a high percentage of the total rainfall. It would indeed be a difficult matter to conceive of a formation more suitable for the absorption of rainfall, than the Columbia sand. In addition to absorbing a large amount of rainfall, the sand also becomes at the same time a perfect filter; and thus it retains near the surface much or all of the organic impurities, which would otherwise contaminate the water below. While the Columbia sand no doubt in general forms a very perfect filter, there are instances, however, which have come under the writer's observation, in which it seemed to produce the opposite effect. These instances were observed only in towns, where the sand formed a thin layer and the surrounding conditions were extremely favorable for surface contamination.

One of the cases, here referred to, was a well at a public boarding-house or small hotel in a town of about 200 inhabitants. The well was situated in the back-yard of the hotel, where the slops from the kitchen were thrown and the cow was penned during the night. Near-by, scarcely three rods away, were the cess-pool and stable, each of which was constantly adding its fetid matter to the thin superficial layer of Columbia sand. An examination of the well showed the following section in the descending order:—

- | | | | |
|---|--|-----|------|
| 1 | Rather coarse sand stained by carbonaceous material..... | 5 | feet |
| 2 | Impervious clay | 3 | " |
| 3 | Sandy clay | 8 | " |
| 4 | Sand | (?) | |

The most reasonable deduction from these conditions may be summed up as follows:

The rain falls upon the sandy soils, where it is contaminated by surface impurities; the water, thus loaded with organic material, is rapidly taken up by the porous sands and carried to the impervious beds of clay below, along which it flows to the well, which it finally

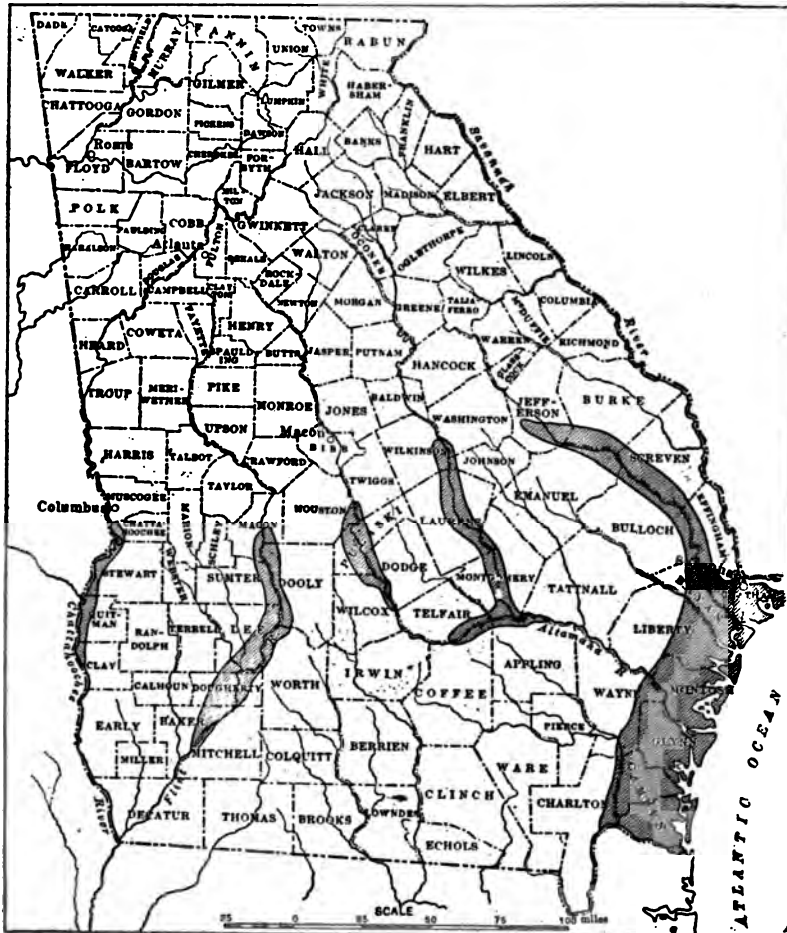


FIG. 1.—Outline Map of Georgia Showing the Areas of Flowing Wells. Shaded Areas Represent Sections in Which Flowing Wells May be Obtained.

enters, to mingle with the purer water at a greater depth. That this is the true explanation of the conditions here exhibited, was ocularly demonstrated by seeing the impure water trickling down the sides of the well along strongly-marked colored lines.

It is no uncommon thing, during the wet season, for the wells penetrating the Columbia to overflow, or for the water to rise within a foot or so of the surface. In some instances, where these sands form heavy deposits, several feet in thickness, they give rise to small springs flowing part of the year.

THE LAFAYETTE. — This formation, by reason of its greater thickness, is a far more important water-carrier than the Columbia sand. The lower layers, when consisting largely of sand, carry large quantities of water, and may give rise to springs of considerable size flowing throughout the year.

A noted spring, of historic interest, flowing from this formation, is the Providence spring at Andersonville, Sumter county. The water supplying this spring comes from the lower beds of the Lafayette, which, at this point, consists largely of coarse sand. Where the Lafayette formation consists largely of impervious clays, it ceases to become a satisfactory source of water for shallow wells. In this case, it protects, no doubt to some extent, the eroded surfaces of the porous strata below, and thereby lessens, to some degree, the total intake area of the deep-seated waters for the entire Coastal Plain.

THE PLIOCENE. — The Pliocene deposits probably furnish considerable water for shallow wells along the Atlantic Coast, where the Columbia and Lafayette formations are absent. They are also, no doubt, the source of supply of the small springs, often met with along the larger streams and swamps. Their chief interest, however, as water-carriers is confined mainly to the deep-seated water-bearing horizons, which have been quite extensively explored from Savannah to St. Mary's.

By an examination of the various drill records of the wells along the Atlantic Coast, given in this report, it will be observed, that there occurs throughout that portion of the Coastal Plain two continuous water-bearing strata. These water-bearing strata, which consist chiefly of sand, occur from 100 to 200 feet apart, and have a low dip to the south and east. The first stratum, in the vicinity of Brunswick, is encountered at a depth of about 350 feet, and the

second, at about 450 feet. At Tarboro, 25 miles southwest of Brunswick, the first stratum is 175 feet below the surface, and the second stratum is 375 feet; while, at St. Mary's, 35 miles south of Brunswick, the depths of these strata vary from 300 to 500 feet.¹ This would indicate a dip to the southeast, of something less than 10 feet per mile. Should this dip remain constant, the outcrop of these water-bearing strata would come to the surface at some point east of Waycross.

In addition to the water-bearing strata, here noted, there is also a third water-bearing stratum reported in some of the wells in Camden county. This stratum is reported to occur in the wells in the vicinity of Satilla Bluff, at a depth of only 60 or 70 feet below the surface. It seems to be of local distribution, and is of little economic importance.

THE MIOCENE. — The Miocene, like the Pliocene, is largely overlain by the Columbia and Lafayette formations; and, as a consequence, it is probably only occasionally penetrated by shallow wells. The springs of the Miocene area are usually small; but, in some instances, as in the case of Gaskin's Spring in Coffee county, near Douglas, they furnish a considerable amount of water. But little seems to be known, at present, of the water-supply of the deep wells of this formation. The upper water-bearing strata of the Savannah, the Jesup and the Waycross wells are probably Miocene; but, so far, the water from these strata seems not to have been used to any extent.

It is also possible, that some of the wells of Effingham and Liberty counties receive their water-supply from Miocene beds. However, the records of these wells are so meagre, that nothing can be definitely stated as to their exact horizon.

THE EOCENE. — The Eocene is the most important water-bearing formation of the Coastal Plain. This is especially true of its upper member, the Vicksburg-Jackson limestone, which is the source of supply of numerous large springs and a large number of deep wells.

Some of the springs, such as Blue Spring in Dougherty county near Albany, compare favorably in size and in the transparency of

¹ Recent study seems to indicate that these water-bearing strata are probably Miocene.

their water with the famous Silver Spring of Florida. These springs are commonly met with, in what is known as the lime-sink region, which usually marks the outcropping of some of the more porous and permeable limestones. In these regions, it is no uncommon thing to see the surface stream disappear underground to reappear again, probably only a few hundred yards away. Such regions are noted for their numerous lime-sinks and small lakes, or ponds, which mark the course of subterranean streams. The flow of the large springs, here referred to, is frequently affected by droughts. In some instances, springs, which ordinarily flow several millions of gallons per day, may, occasionally, during a long drought, entirely cease to flow.

In addition to the large springs, here referred to, there are also a great number of smaller springs throughout the Eocene area, which furnish ample and continuous water-supply for domestic purposes.

The shallow wells of the Eocene area are confined chiefly to the superficial deposits, Columbia and Lafayette; but, in some localities where these deposits have been removed by erosion, the wells obtain their water-supply from the Eocene beds. The water of shallow wells, when obtained from limestones, is usually considered unwholesome; but, on the other hand, if the source is the sands, it is considered quite wholesome.

The Eocene beds, whenever pierced by the drill to any considerable depth, are found to furnish an abundant supply of water. The wells at Savannah, Waycross, Valdosta, Bainbridge and a large number of the smaller towns throughout the southeastern part of the Coastal Plain north of the Atlantic Coast Line Railroad, obtain their water-supply from the Eocene beds. The water-bearing beds consist of porous limestones and sands. In the deeper wells, two of these water-bearing strata, and sometimes three, are encountered. They are usually several feet in thickness, and continue apparently with but little change in dip or lithological character, for a long distance.

THE CRETACEOUS. — The Cretaceous rocks, as previously noted, occupy only a comparatively small area along the northern margin of the Coastal Plain. These rocks, however, on account of their loose

texture and gentle slope to the southward are water-carriers, of considerable economic importance. The shallow wells of the Cretaceous area obtain their water-supply chiefly from the Lafayette formation. These wells, in some instances, no doubt penetrate the Cretaceous beds; but such wells are probably confined largely to places where the superficial deposits have been removed. The springs of the Cretaceous area are usually small, and are rarely met with, except along streams where they mostly occur as seepage from the adjacent hills. There are probably but few springs in the area that furnish as much as 100 gallons per minute.

The chief interest in the Cretaceous beds as water-carriers lies in their deep-seated water-bearing strata. These strata seem to be several in number; but, as a general rule, they are not so continuous or so reliable as the Eocene strata. Some of the wells, which may be mentioned as obtaining their water-supply from the Cretaceous beds, are the Sandersville well, the Perry well, the Marshallville well, the Dawsonville well, the Fort Gaines well and the Montezuma wells. The lowest water-bearing stratum of the Albany deep well also belongs to the Cretaceous rocks, as well as the lowest water-bearing stratum in the Blakely well. The water from the deep wells of the Cretaceous deposits is generally soft, and is well suited for domestic and technical purposes.

THE CRYSTALLINE ROCKS. — The Piedmont Plateau, including the Appalachian Mountain division, which consists of the Crystalline rocks, is a region noted for its great number of springs and shallow wells. Nearly every ravine and hollow, throughout the entire area, is supplied by never-ceasing springs, which, though usually small, furnish ample water for domestic purposes. In addition to these small springs, there also occur, in some localities, springs which furnish large volumes of water. The latter are usually found in quartzite and limestone, or other undoubted clastics. Some of the most noted of these large springs occur along Pine Mountain in Meriwether and Harris counties, and in Hall county, near Gainesville. Cold Spring, in Meriwether county, furnishes more than 2,000 gallons per minute, and Warm Springs, near by, has nearly an equal capacity. These large springs, like the small ones, are but

little affected by the drought, and can always be relied upon to furnish a constant supply of water.

The abundance of the springs of the Crystalline area seems to be due chiefly to the structural geology of the region. The rocks, besides being largely of a complex and heterogeneous character, are much folded, contorted, fissured and sheared. Such rocks absorb a comparatively high percentage of rainfall, which, after a short course underground, is again brought to the surface, by folds or fissures of the strata, to form springs. As none of the rocks of the area are, strictly speaking, pervious or impervious, all may be said to be water-carriers, to a greater or less extent. Springs, therefore, have no regular distribution, but are pretty evenly distributed throughout the region.

The conditions for shallow wells in the Piedmont Plateau are quite favorable. The entire area is usually covered, to a depth of many feet, with a mantle of somewhat sandy clays, which have resulted from the weathering of the underlying granites, gneisses, schists, etc. These lower layers of the residual clays are almost invariably saturated with water, which is a continuous source of supply to shallow wells of the region, except during long continued droughts. This class of wells has an extensive use throughout the Piedmont Plateau and the Appalachian Mountain divisions of the State. They are the main source of domestic water-supply for the rural districts, as well as for the small towns. The deep wells of the Crystalline rocks have not, as a general rule, been successful. In the majority of cases, the amount of water secured has been inadequate to supply the demand, for which such wells are constructed. In a few instances, however, as in the case of some of the Atlanta and Augusta wells, this class of wells furnish ample water to supply large manufacturing plants.

THE PALEOZOIC ROCKS. — The main water-bearing strata of the Paleozoic rocks are the limestones and the sandstones. The Paleozoic limestones and sandstones, together with their associated shales, have been thrown by lateral pressure into a number of long anticlinal and synclinal folds. The anticlinal folds, in most cases, have been decapitated, and are now replaced by valleys of erosion, while

the synclinal form the intervening ridges. These structural conditions are usually unfavorable for flowing-wells; but, at the same time, they materially affect the underground water-supply by permitting the rainfall to be freely taken up by the upturned edges of the strata. These structural conditions also account for the numerous springs of the region, as well as for their local distribution. The limestones, which are the main source of underground water-supply of the region, are the Chickamauga limestone and the Knox dolomite. The former has been quite extensively prospected for water by deep borings in the vicinity of Chickamauga Park. The majority of these wells, together with the deep wells in the same formation at Cedartown and Rockmart, furnish considerable water; but, in most instances, the water is obtained from fissures or cavities, and not from any special water-bearing bed. The same conditions, met with in the Chickamauga limestone, seem to occur in the Knox dolomite, at such places as have been prospected with the drill.

The sandstones, which are above referred to as water-carriers, are confined chiefly to Sand and Lookout mountains. At several points on these mountains, bore-holes, put down in prospecting for coal, have furnished considerable supplies of water. The various coal mines, located on these mountains, also show that the sandstones are water-carriers of importance. In addition to the deep wells, here referred to, there are also present throughout the Paleozoic area very favorable conditions for successful shallow wells. The residual clays of the region, which usually take up a comparatively high percentage of the rainfall, are generally of such thickness, as to retain sufficient water to furnish ample supply for all ordinary domestic purposes. The Paleozoic, like the Crystalline area, is noted for its numerous springs. These springs, some of which furnish enormous quantities of water, are found most abundant in the limestone belts, or near the contact of the limestones and sandstones with the shales. Faults, also, to some extent, often govern the distribution of springs. The waters of the large springs frequently become muddy after a heavy rainfall; and occasionally, during a long drought, they become much reduced in volume. The smaller springs, on the other hand, seem to be but little affected by the seasons.

CHAPTER V

THE MINERAL CONSTITUENTS OF THE DEEP-WELL WATERS OF THE COASTAL PLAIN.

The mineral constituents of the deep-well waters of the Coastal Plain vary from 70 to 1,160 parts per million. The total amount of these constituents present, and the ratio they bear to each other, depend largely upon the character of the water-bearing strata, from which the water is obtained. Thus, waters from highly calcareous rocks, such as the Eocene limestone, will carry a higher percentage of mineral matter than waters from the Cretaceous sands. In the one case, the chief mineral constituent is carbonate of lime, and in the other, silica. Another element, which governs, to a greater or less extent, the total amount of mineral matter held in solution in the deep-well waters of the Coastal Plain, is the depth of the water-bearing strata below the surface. Other things being equal, the greater the depth, the greater will be the amount of mineral matter held in solution. The water-bearing strata of the Cretaceous rocks are usually sands; and they therefore almost invariably yield soft waters. This is especially true of that part of the formation west of the Flint River, as is shown by the analysis of the water from the lower water-bearing stratum of the Albany well, and also by the analyses of the waters from the deep wells at Montezuma, Fort Gaines and Blakeley, all of which get their water-supply from the Cretaceous sands. These soft Cretaceous waters, which are well adapted for technical purposes, can be had, over a large area west of the Flint River, by sinking wells to a depth varying from 400 to 1,200 feet.

In contrast with these soft Cretaceous waters, are the almost universally hard Eocene waters. These hard waters supply the deep wells of a greater part of the Coastal Plain. They are encountered in the Savannah and Waycross wells at depths varying from 400 to



A. VIEW SHOWING THE UNCONFORMITY BETWEEN A MANTLE OF LAFAYETTE SAND AND FIRR-CLAY BEDS AT STEVENS POTTERY, BALDWIN COUNTY, GEORGIA.



500 feet, and are the main source of the deep-well supply, as far north as Dublin and Hawkinsville. These waters usually carry from 50 to 175 parts per million of calcium carbonate, besides a considerable amount of magnesium carbonate. The Miocene and Pliocene deep-well waters usually differ but little from the Eocene waters. They all carry more or less calcium carbonate, and are generally unsatisfactory for boiler use.

One rather interesting feature of the deep-well waters of the Coastal Plain, shown by the chemical analyses, is the remarkably high percentage of phosphoric acid present in some of these waters. This peculiarity is well illustrated by the analysis of the Baxley deep-well water, which carries 4 parts per million of phosphoric acid. These waters, with high phosphoric acid contents, appear to be confined to no special geological horizon. They are found in the Cretaceous and Eocene, as well as in the Pliocene. It has been suggested, that, if these phosphatic waters were used for irrigation purposes, commercial fertilizers might, in a large measure, be dispensed with; as 12 inches of water, used in irrigation, would be equal to nearly 200 pounds of commercial fertilizer per acre.

CHAPTER VI

DETAILED DESCRIPTION OF THE UNDERGROUND WATERS OF THE COASTAL PLAIN BY COUNTIES

APPLING COUNTY

The main sources of the domestic water-supply in Appling county, at present, are the shallow wells. These wells usually vary from 15 to 30 feet in depth, and furnish an abundant supply of soft water. The source of supply of these wells appears to be mainly the Columbia and Lafayette sands and clays. However, in some instances, it is more than likely, that they penetrate the underlying Miocene beds.

BAXLEY. — (*Elevation, 205 feet above sea-level.*) The only deep wells in the county are at Baxley, the county seat. One of these wells has a depth of 525 feet, and the other, a depth of 461 feet. The former, which is located about 100 feet from the latter, met with an accident before its completion; and it was finally abandoned. The well, having a depth of 461 feet, is 8 inches in diameter and is cased to 206 feet. The water-supply of this well, at present, is said to come from a water-bearing stratum at 210 feet from the surface. A second water-bearing stratum is reported at 408 feet; but no information was obtained as to the lithological character, or the thickness of these beds. The water from the first stratum rises to within 90 feet of the surface. It is soft, clear, and well suited for domestic and manufacturing purposes, as is shown by the following analysis, made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia: —

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	97.10	5.662
Sulphur Trioxide	1.34	.080
Carbon Dioxide	50.20	2.930
Phosphorus Pentoxide	4.00	.233
Chlorine	12.20	.711
Iron Sesqui-oxide and Alumina.....	16.56	.971
Lime	5.50	.321
Magnesia	1.19	.069
Potash	5.33	.311
Soda	17.79	1.037
Total Hardness	84.70	4.939
<i>Probable Combination</i>		
Potassium Chloride	8.76	.511
Sodium Chloride	13.22	.771
Sodium Sulphate	3.14	.183
Sodium Phosphate	8.00	.466
Sodium Carbonate	10.14	.591
Magnesium Carbonate	2.50	.146
Calcium Carbonate	9.82	.572
Total Solids	169.24	9.869
Free Carbon Dioxide.....	40.36	2.353

Sandstone, marl and shell rock are said to have been penetrated in the Baxley wells; but the thickness and order of succession of these beds could not be ascertained. The water-bearing strata of these wells are probably upper Eocene or lower Miocene.

BAKER COUNTY

Baker county has numerous springs; but the chief sources of water-supply for domestic purposes are surface wells, which vary from 30 to 50 feet in depth. Many of the springs of the county furnish large volumes of water; but they are usually located near the banks of the larger streams, and are subject to overflow during the wet season.

Lester's Spring on the Flint River, eight miles northeast of Newton, and the so-called Blue Spring, within the corporate limits of

- Newton, are good examples of the larger springs often met with in Baker county. The shallow wells are confined chiefly to the Columbia and Lafayette formations; though, in some cases, these wells enter the underlying Eocene limestones. The water obtained from the latter deposits is usually quite hard, and is generally regarded as unhealthful.

NEWTON. — The artesian well at Newton, which was completed in October, 1902, is the only deep well in the county. This well is two inches in diameter and 825 feet deep, and has a constant flow of 15 gallons per minute. The water rises 35 feet above the surface. Mr. J. B. Perry gives the following very meagre and imperfect record of the Newton well: —

1	Sands and clays.....	to 80 feet
2	Rock	" 380 "
3	Quicksand and rock.....	" 580 "
4	Marl, sand and rock.....	" 680 "
5	Marl	" 800 "
6	White honeycombed rock.....	" 825 "

The record of the well, here given, seems to correspond fairly well with the record of the Albany wells; and the water-supply is, therefore, thought to come from the upper beds of the Cretaceous.

The analysis of the water from the Newton well, made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia, is as follows: —

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	19.80	1.155
Sulphur Trioxide	7.75	.452
Carbon Dioxide	190.80	11.117
Chlorine	7.00	.408
Iron Sesqui-oxide and Alumina	3.56	.208
Lime	6.31	.368
Magnesia	5.25	.306
Potash	2.32	.106
Soda	78.83	4.656
Total Hardness	26.60	1.551
Permanent Hardness	22.80	1.329

<i>Probable Combination</i>	Parts per Million	Grains per U. S. Gallon
Potassium Chloride	3.68	.215
Sodium Chloride	8.65	.504
Sodium Sulphate	13.75	.802
Sodium Phosphate	trace	trace
Sodium Carbonate	118.39	6.904
Magnesium Carbonate	11.02	.643
Calcium Carbonate	11.27	.657
Total Solids	190.12	11.087
Free Carbon Dioxide.....	130.92	7.635

BERRIEN COUNTY

Shallow wells are the chief source of the domestic water-supply in Berrien county. No springs of importance are reported. Successful deep wells have been completed at Adel, Tifton and Milltown.

ADEL. — (*Elevation, 246 feet above sea-level.*) The Adel well, completed in 1893, is 4½ inches in diameter and 280 feet deep. The water rises to within 154 feet of the surface. Mr. J. B. Spencer furnishes the following record:—

1	Sandy soil	2	feet
2	Red clay	10	"
3	White sand	10	"
4	Blue clay with sandstone bowlders.....	125	"
5	Fine white sand	25	"
6	Limestone with thin layers of flint.....	100	"

The main water-supply in this well is said to come from the limestone, 229 feet from the surface.

TIFTON. — (*Elevation, 343 feet above sea-level.*) Capt. H. H. Tift's well, at Tifton, was completed in 1896, at a depth of 360 feet. It is 8 inches in diameter. Water rises to within 80 feet of the surface. Two or three water-bearing strata are reported; but their depths were not given. Limestone is said to have been struck at 260 feet.

The following analysis of the water from the Tift well was made by Dr. H. C. White, of the University of Georgia:—

<i>Solids Dissolved</i>	Grains per Gallon
Carbonate of Lime.....	10.642
Carbonate of Soda.....	0.579
Carbonate of Iron.....	0.013
Carbonate of Magnesia	0.149
Sulphate of Potash.....	0.536
Sulphate of Soda	0.641
Sodium Chloride	0.065
Alumina	0.614
Silica .....	.932
Organic Matter .....	.411
	Parts per Million
Free Ammonia	none
Albuminoid Ammonia	0.020
Color	clear
Odor	none
Sediment	none

The following notes, made by Mr. W. W. Burnham on the Tifton Ice and Power Company's well, have been furnished by Mr. M. O. Leighton, Chief of the Division of Hydro-Economics, U. S. Geological Survey:—

"The well is located near the station, about 10 feet above the railroad track. It is 6 inches in diameter, 572½ feet deep, and is used chiefly to supply an ice factory. The water rises to within 115 feet of the surface. It is raised with an air lift having a maximum capacity of 135 gallons per minute. The well cost \$2,000, and the pumping plant, \$1,000. The section of the well is as follows:—

1	Surface soil	—	feet
2	Clay and sand	30	"
3	Sand rock	20	"
4	Rock and clay (20-foot layers).....	100	"
5	Quicksand	25	"
6	From 270 to 300, hard flint.....	28	"
7	From 300 to 512, porous limestone.....	212	"

Water in caverns at 340 and 512 feet."

The following field analysis of water from the Tifton Ice and Power Company's well was made by Mr. W. W. Burnham.¹

<i>Constituents Determined</i>	<i>Parts per Million</i>
Chlorine	4.0
Total Carbonates as Calcium Carbonate.....	116.0
Scale-forming Carbonates as Calcium Carbonate..	38.0
Alkali Carbonates as Sodium Carbonate.....	82.6
Total Hardness as Calcium Carbonate.....	—
Sulphur Trioxide	none
Iron	0.5
Odor (air-lift) Hydrogen Sulphide.....	1.0
Color	none
Turbidity	none
Temperature	—

Analysis of the same water by Boiler Compound Company is as follows:

<i>Constituents Determined</i>	<i>Grains per Gallon</i>
Sodium Chloride	1.18
Calcium Sulphate	4.11
Magnesium Carbonate .....	.99
Calcium Carbonate	2.11
Silica .....	.92
Iron Oxide and Alumina.....	.22
Total	10.26

MILLTOWN. — The G. V. Gress Lumber Company's well, located at Milltown, was completed October 25th, 1903. The well is 6 inches in diameter and 260 feet deep; and it furnishes a good supply of sulphureted water, rising to within 80 feet of the surface. The

¹ EXPLANATORY NOTE — Total carbonates are determined by ascertaining amount of acid used up by the alkalinity of the water. It is expressed in terms of Ca CO_3 , but may not necessarily be wholly calcium carbonate. The scale forming carbonates, as determined in this series of tests, should be looked upon rather with suspicion. As a field method it was a new one and had not been sufficiently tried. In the determination of scale-forming carbonates, the sample was boiled, titrated with acid, and calculated as Ca CO_3 . This subtracted from total carbonates gave the carbonates precipitated on boiling, which have been designated as scale-forming carbonates. If the amount of these is correct it probably gives a fair idea of the calcium carbonate content of the water. Total hardness as Ca CO_3 was determined by titrating with a standard soap solution and is merely expressed as calcium carbonate in order to have some convenient scale of reference. The total hardness, as will probably be noticed, seems to be dependent upon the sulphates in the water. So that, outside of being indicative of the industrial value of the water, it merely serves as a check upon the carbonates and sulphates.

main water-supply is said to come from sand, 100 feet from the surface. The water is used for drinking and other purposes.

The water-bearing strata of the Adel and Tifton wells is Vicksburg-Jackson limestone; but the Milltown well probably obtains its supply from the Miocene sands.

BIBB COUNTY

The fall-line, separating the Coastal Plain from the Crystalline area, divides Bibb county into two nearly equal divisions. The northern portion, which consists of the Crystalline rocks, is well supplied with small springs; but the main reliance for domestic water-supply is shallow wells. South of the fall-line, or within the Coastal Plain area, in addition to springs and shallow wells, there is also a number of deep wells.

MACON. — (*Elevation, 333 feet above sea-level.*) One of the first attempts to obtain water in Bibb county, by means of deep boring, was made by the Acme Brewing Company in the city of Macon in 1890. This well, which is located less than a mile south of the contact of the Crystalline rocks with the Cretaceous, is said to attain a depth of 955 feet. With the exception of the first one or two hundred feet, which consist of the Columbia and Lafayette and Cretaceous sands and clays, the well penetrated the Crystalline rocks. These last, and also the overlying clastics at this point, were found to be practically barren of water, and the well was therefore unsuccessful. South of Macon, the condition for successful deep wells seem to be more promising. However, even in that portion of the county, these wells have not met with success, in all cases. In most instances, water-bearing strata were penetrated; but quick-sands were often difficult to control, and, at any time, likely to shut off or decrease the water supply.

Mr. H. R. Teal, a well contractor, who has had considerable experience in constructing wells in the southern part of Bibb county, informs the writer, that the water-bearing beds of the region are very variable, and that, in some places, they appear to be entirely wanting, or furnish only a meagre supply.



A VIEW ON THE CHATAHOOCHEE RIVER, OPPOSITE COLUMBUS, GEORGIA, SHOWING THE CRYSTALLINE ROCKS OF THE
PIEDMONT PLATEAU, OVERLAIN BY THE CRETACEOUS AND COLUMBIA FORMATIONS.



The J. D. Whiteside well is located on the Macon-Perry public road, seven miles south of Macon. It was completed in 1899; and it has a depth of 190 feet, and is three inches in diameter. No data were secured concerning the various strata penetrated in its construction. The water, at present, is reported to stand within 90 feet of the surface, and to come from gravel beds at some point near the bottom of the well.

WALDEN. — Mr. J. B. Willis's well, near Walden, is reported to have a depth of 260 feet, and to yield two gallons per minute. The water rises to within 80 feet of the surface, and is remarkably pure, as is shown by the following analysis, made by Mr. A. M. Lloyd, of Atlanta: —

<i>Constituents Determined</i>	<i>Grains per U. S. Gallon</i>
Carbonate of Lime.....	0.2436
Carbonate of Magnesia.....	0.1136
Sesqui-oxide of Iron and Alumina.....	0.1456
Sodium Chloride.....	0.1654
Potassium Sulphate.....	0.1306
Silica.....	0.4785
Sodium Silicate.....	0.0727
Organic and Volatile Matter.....	0.0330
Total Solids.....	1.3830

In addition to the deep well, just described, there are two others located in the vicinity of Walden, from which partial reports have been secured. One of these wells, owned by Mr. B. F. Vinson, is four inches in diameter, and has a depth of 185 feet. The water, which rises within 80 feet of the surface, is reported to come from sand near the bottom of the well. A water-bearing stratum is also said to occur, 75 feet below the surface. The other well, above referred to, owned by Mr. W. J. Willis, has the same diameter as the Vinson well; but it is only 165 feet deep. The water in this well rises to within 60 feet of the surface, and is reported to come from a bed of coarse sand and gravel at the bottom. Mr. Willis notes the occurrence of flint (?) rock, 20 feet thick, in this well, at a depth of 115 feet, and also, a soft rock, about the same thickness, only a few feet above the water-bearing stratum.

The water-supply of all the deep wells in Bibb county appears to come from the basal member of the Cretaceous deposits, or the Potomac formation. However, the records of the wells are too meagre, to give any detailed description of these beds.

BROOKS COUNTY

With the exception of the town of Quitman, the entire domestic water-supply of Brooks county is practically obtained from the shallow wells, which penetrate the Lafayette sandy clays, or the underlying Miocene beds. There are a few large springs in the county; but they are always located in more or less inaccessible places; and, as a result, they are only occasionally used for domestic, or other purposes. There is, however, in the case of the so-called Blue or Wade Mineral-spring, a rather marked exception to this general rule. This spring, which is located near the right bank of the Withlacoochee River, seven miles east of Quitman, has, in recent years, become quite a local pleasure resort. The improvements consist of a small hotel, or boarding-house, and a number of cottages, for the accommodation of guests. The spring is a typical so-called blue spring, of the limestone region of South Georgia. It seems to be the outlet of a large subterranean stream, which ascends, with considerable force, through a large opening. At the time of the writer's visit to the spring, in November, 1903, a rough estimate showed, that it was then flowing about 15 million gallons per day. It was learned, however, that, during an extremely dry season, some years ago, the spring went dry. Another of these large springs, known as the McIntyre Spring, having probably twice the capacity of the Blue Spring, is to be seen in Withlacoochee River, near the Georgia-Florida line, 15 miles southeast of Quitman.

QUITMAN. — (*Elevation, 181 feet above sea-level.*) The deep wells of Brooks county are confined to Quitman and vicinity. The first of these wells, which is said to have attained a depth of 500 feet, was constructed by the town of Quitman, at a cost of about \$3,000, in 1884.

Dr. J. W. Spencer, formerly State Geologist of Georgia, gives the following record of the well:—¹

1	Clay and sand to.....	70 feet
2	Soft rock in seams to.....	100 "
	Rock 3 ft., after which the drill fell 6 ft. into a stream of water to.....	109 "
3	Soft rock and sand to.....	186 "
4	Hard flint rock.....	thin layer
5	Quicksand and hard rock in beds, 1 to 3 ft. thick to.....	300 feet
6	Sand and clay to.....	340 "
7	Sand to	385 "

Since the completion of the well, here described, three other deep wells have been put down, within the corporate limits of Quitman. One of these wells, which is located at the pumping-station, and now supplies the town with water, has a depth of 321 feet. It penetrates water-bearing strata at depths of 123 and 310 feet. Both of these water-bearing strata furnish a large supply of water.

The analysis of the water from the second water-bearing stratum, made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia, is as follows:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	28.10	1.639
Sulphur Trioxide	trace	trace
Carbon Dioxide	176.00	10.263
Phosphorus Pentoxide	trace	trace
Chlorine	5.80	.338
Alumina	5.00	.291
Iron Sesqui-oxide	18.80	1.095
Lime	32.50	1.924
Magnesia	15.10	.880
Potash	0.80	.046
Soda	5.50	.321

¹ Geol. Surv. of Georgia, First Report of Progress, 1891, p. 74.

<i>Probable Combination</i>	Parts per Million	Grains per U. S. Gallon
Potassium Chloride	1.30	.075
Sodium Chloride	8.60	.501
Sodium Phosphate	trace	trace
Sodium Carbonate	1.80	.105
Calcium Carbonate	58.00	3.382
Magnesium Carbonate	31.70	1.848
Total Solids	153.30	8.940
Free Carbon Dioxide	133.13	8.764

The two other wells, above referred to, within the city limits of Quitman, attain depths of 120 and 310 feet, respectively. The shallower well shows the following record:—

1	Surface sands	to	2 feet
2	Vari-colored clay	"	62 "
3	Yellow sand	"	77 "
4	Gray, sandy clay	"	120 "
5	Porous limestone (water-bearing)		(?)

The first water-bearing stratum, in all the deep wells of Quitman, appears to be a cavernous limestone, which is always readily recognized, by the dropping of the drill from 2 to 9 feet, when it is first encountered. The deep well at the Oglesby Mill, three-quarters of a mile northwest of Quitman, and also the Quitman Power Company's well, about two miles northeast of Quitman, each penetrate and receive their water-supply from this cavernous limestone.

The water-bearing strata in the Quitman wells appear to belong to the Upper Vicksburg-Jackson rocks.

BRYAN COUNTY

The domestic water-supply of Bryan county is derived almost entirely either from dug or driven wells, which vary from 15 to 30 feet in depth.

No springs of any importance are reported in the county. The only deep wells are located at or near Way's station in the eastern part of the county, a short distance west of the Ogeechee River.

There are four of these wells, the first of which was put down by the Florida Central and Peninsular Railroad, now the Seaboard Air Line Railway, in 1895. This well, located about half-a-mile west of the river, is three inches in diameter, and 460 feet deep, and furnishes a flow, 20 feet above the surface. Water-bearing strata are reported at 340 and 440 feet, respectively. The water is used to supply the water-tank of the railroad; and it is also used by the people living near by, for drinking and general domestic purposes.

The following field-analysis of water from this well, made by Mr. W. W. Burnham, was furnished by M. O. Leighton, Chief of the Division of Hydro-Economics, U. S. Geological Survey:—

<i>Constituents Determined</i>	Parts per Million
Chlorine	6.5
Total Carbonates as Calcium Carbonate.....	104.0
Scale-forming Carbonates as Calcium Carbonate..	21.0
Alkali Carbonates as Sodium Carbonate.....	88.0
Total Hardness as Calcium Carbonate.....	124.0
Sulphur Trioxide	trace
Iron	0.5
Odor, Hydrogen Sulphide	2.0
Color	none
Turbidity	none
Temperature, F. (estimated).....	72°

Mr. Burnham secured the following notes from Mr. Bailey Carpenter, on his well located at Way's station: Depth, 345 feet; diameter, 1½ inches; flow, 25 feet above the surface. The water is used for domestic purposes.

The field-analysis of the water from the Carpenter well, by Mr. Burnham, is as follows:—

<i>Constituents Determined</i>	Parts per Million
Chlorine	4.0
Total Carbonates as Calcium Carbonate.....	111.0
Scale-forming Carbonates as Calcium Carbonate..	8.0
Alkali Carbonates as Sodium Carbonate.....	109.0
Total Hardness as Calcium Carbonate.....	110.0
Sulphur Trioxide	trace
Iron	trace

	Parts per Million
Odor, Hydrogen Sulphide.....	3.0
Color	none
Turbidity	none
Temperature, F. (estimated).....	70°

BULLOCH COUNTY

The only deep wells, reported in Bulloch county, are located at Statesboro, the county-seat. There are three of these wells; but no report has been received from any of them, except the one owned by Mr. W. D. Davis. This well has a depth of 320 feet, and furnishes an abundance of excellent water, the analysis of which, made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia, is as follows:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	43.10	2.513
Sulphur Trioxide	2.86	.170
Carbon Dioxide	5.42	.316
Phosphorus Pentoxide	trace	trace
Chlorine	6.80	.397
Iron Sesqui-oxide and Alumina.....	5.00	.292
Lime	2.12	.124
Magnesia	1.28	.075
Potash	3.32	.194
Soda	3.95	.230
<i>Probable Combination</i>		
Potassium Chloride	5.26	.307
Sodium Chloride	7.08	.413
Sodium Sulphate	0.45	.026
Sodium Phosphate	trace	trace
Magnesium Sulphate	3.84	.224
Calcium Sulphate	1.17	.068
Calcium Carbonate	2.93	.171
Total	68.83	4.014
Free Carbon Dioxide.....	4.13	.241

The Statesboro wells are all non-flowing. They probably receive their water-supply from the Upper Eocene beds. There are few springs in Bulloch county. The chief water-supply is obtained from shallow wells.

BURKE COUNTY

Successful deep wells have been constructed in Burke county at Waynesboro, Herndon, Rogers and Midville.

WAYNESBORO. — (*Elevation, 286 feet above sea-level.*) There are two deep wells at Waynesboro, one owned by Mr. W. A. Wilkins and the other by the Southern Cotton Seed Oil Company. The former well, which was put down in 1888, is reported to have a depth of 889 feet. Water-bearing strata are said to occur in this well at depths of 250, 300 and 889 feet. The water-supply, at present, is obtained from the upper stratum. The water rises to within 14 feet of the surface, and is said to be of good quality.

Mr. R. G. Edenfield, of Augusta, Ga., has furnished the writer with a number of samples of borings from this well, on which the following notes have been made: —

1	Fine, red sand.....	to 60 feet
2	Yellow sand	" 150 "
3	Coarse, white sand with fragments of shells....	" 230 "
4	Rather coarse, gray sand.....	" 240 "
5	Sandy marl	" 290 "
6	Fine, yellow sand	" 310 "
7	Very coarse sand with dark-colored pebbles, numerous minute crystals of gypsum, and fragments of tough gray clay.....	" 340 "
8	Coarse sand	" 360 "
9	Dark sandy clay with sharks' teeth.....	" 380 "
10	Coarse sand	" 410 "
11	The same as above.....	" 500 "
12	Coarse sand, mixed with red micaceous clay...	" 700 "

Considerable limestone and flint are reported to occur in the Wilkins well; but their depth from the surface, and the thickness could not be ascertained.

The Southern Cotton Seed Oil Company's well has a depth of about 200 feet. It is 6 inches in diameter, and furnishes daily, by pumping, 1,200 gallons of water, which supplies the oil mill and a number of residences in the town. The water rises to within 19 feet of the surface, and is of good quality, as is shown by the following analysis, made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	15.50	.878
Sulphur Trioxide	3.06	.178
Carbon Dioxide	152.00	10.864
Phosphorus Pentoxide	trace	trace
Chlorine	7.00	.408
Iron Sesqui-oxide and Alumina.....	6.06	.353
Lime	87.12	.5.081
Magnesia	3.31	.193
Potash	2.12	.124
Soda	4.84	.282
<i>Probable Combination</i>		
Potassium Chloride	3.36	.196
Sodium Chloride	8.90	.519
Sodium Sulphate	0.30	.015
Sodium Phosphate	trace	trace
Magnesium Sulphate	4.76	.278
Magnesium Carbonate	3.90	.227
Calcium Carbonate	155.57	9.073
Total Solids	198.35	11.567
Free Carbon Dioxide	81.51	4.753

HERNDON. — (*Elevation, 189 feet above sea-level.*) The Herndon well is two inches in diameter and 300 feet deep, and furnishes 30 gallons of water per minute. The water is hard, but wholesome; and it rises 14 feet above the surface. Quicksand, marl and honey-combed limestone are said to have been penetrated, in sinking the Herndon well; but neither their order of occurrence nor their thickness were ascertained. The water-supply is reported to come from a porous limestone near the bottom of the well.

ROGERS. — (*Elevation, 201 feet above sea-level.*) The well at Rogers is 51 feet deeper than the Herndon well; it is four inches in diameter, and furnishes a flow of 80 gallons per minute. The water rises 24 feet above the surface. Two water-bearing strata are reported in the Rogers well, one at a depth of 180 feet and the other at 330 feet. Mr. H. M. Lloyd, well contractor, gives the following record: —

1	Blue clay	to	5 feet
2	Fine, white sand	"	60 "
3	Blue marl	"	180 "
4	Black sand (water-bearing)	"	182 "
5	Blue marl and rock; last 50 feet, soft rock.....	"	351 "

MIDVILLE. — Midville has 10 flowing wells, varying in depth from 157 to 305 feet. The deeper wells are reported to have penetrated water-bearing strata at 50, 150, 190 and 295 feet, respectively. The static head of the water from the third stratum is said to be 40 feet above the surface, and from the second stratum, 27 feet.

Mr. Allen W. Jones, the owner of three of the Midville wells, attempted to utilize his wells in operating a small electric-light plant; but the power was found to be insufficient to execute the work.

Mr. W. H. Boston gives the following meagre record of the public well at Midville, from memory: —

1	Surface	to	10 feet
2	White sand	"	35 "
3	Limestone, underground stream	"	55 "
4	Limestone, pebbles with shells and sharks' teeth. "	105 "	
5	Limestone, underground stream	"	111 "
6	Honey-combed water-bearing rock	"	157 "

The following field-analyses of the waters from the Midville wells, made by Mr. W. W. Burnham, were furnished by Mr. M. O. Leighton, Chief of the Division Hydro-Economics, U. S. Geological Survey: —

<i>Constituents Determined</i>	No. 1	No. 2
	Parts per Million	Parts per Million
Chlorine	4.0	4.0
Total Carbonates as Calcium Carbonates.....	100.0	150.0
Scale-forming Carbonates, as Calcium Carbonate	6.2	14.0
Alkali Carbonates, as Sodium Carbonate.....	99.5	144.0
Total Hardness as Calcium Carbonate.....	125.0	167.0
Sulphur Trioxide	10.0	5.0
Iron	0.5	0.5
Odor, Hydrogen-Sulphide	3.0	3.0
Color	none	none
Turbidity	none	none
Temperature, F. (estimated).....	70°	

In addition to the deep wells, here described, there are others in Burke county; but no definite data have been received, which would give any additional information concerning the character of the formations penetrated. Nothing definite can be stated, as to the geological horizon of the different water-bearing strata of Burke county, further than that they are all probably Eocene, except possibly the third water-bearing stratum in the Wilkins well at Waynesboro, which may be Cretaceous.

The only large spring, visited in Burke county, is located about seven miles north of Millen. This spring, which flows several million gallons daily, seems to be the outlet of an underground stream, which can be followed for some distance by a chain of lime-sinks. The water from this spring was formerly used to operate a grist mill, ginnery etc.; but some time ago a sink suddenly appeared in the storage basin, and the water disappeared underground. An effort was made to fill the sink with brush, rock etc.; but it was unsuccessful; and, as a result the mill had to be abandoned.

The main supply of water for domestic purposes is obtained from shallow wells. These wells, which vary from 20 to 50 feet in depth, are confined chiefly to the Lafayette; though, in some cases, they no doubt penetrate the underlying Miocene, or the Eocene.

CAMDEN COUNTY

Camden county seems to have no springs of importance, except a few small mineral springs, which are only of local interest. Shallow wells are the chief source of the domestic water-supply in the rural districts; but, in the small towns and on many of the large plantations, deep wells are in general use.

ST. MARY'S. — The deep well at St. Mary's, the county-seat, is four inches in diameter, and has a depth of 522 feet. Two water-bearing strata occur in this well, one at 300 feet, and the other, at 500 feet. The present water-supply is obtained from the lower stratum, the upper stratum being cased off. The water from the former stratum rises 50 feet above the surface, or about 40 feet above high tide. It is said to be quite wholesome, and is generally used by the people of the town for domestic purposes. The water is rather heavily charged with hydrogen sulphide, and forms a white precipitate about the overflow pipes.

The following chemical analysis was made by Dr. Geo. F. Payne, former State Chemist: —

Total Solids per U. S. Gallon.....	29.58	grains
Chlorine	2.49	"
Free Ammonia per Million.....	0.20	parts
Albuminoid Ammonia per Million.....	0.60	"

The water also contains iron, alumina, lime, magnesia, sulphuric acid, soda and potash. It is regarded, among the inhabitants of St. Mary's, as having marked medicinal properties.

CUMBERLAND ISLAND. — Mrs. Lucy Carnegie's well, located on the beach at Dungeness near the southern end of Cumberland Island, is 680 feet deep and six inches in diameter. The water is sulphurated; and it rises 51 feet above the surface. The daily capacity of the well is estimated at 800,000 gallons. The number of water-bearing strata is not given; however, the notes furnished by Mr. O. H. Wade, the well contractor, show that the first flow was obtained at 400 feet in a white, chalky limestone. Four other flowing

wells are reported on Cumberland Island, ranging in depth from 400 to 700 feet. Two of these wells are located at the famous resort on the north end of the island. They furnish an abundant supply of water, which is said to be excellent for dyspeptic troubles. The water from these wells rises only 12 feet above the surface.

KINGSLAND. — (*Elevation, 75 feet (?) above sea-level.*) Mr. W. H. King's well, which supplies the water-tanks of the Seaboard Air Line railroad at Kingsland with water, has a depth of 500 feet. It is two inches in diameter, and furnishes about 800 gallons per minute. The water rises 25 feet above the surface. Water-bearing strata are reported at 350 and 450 feet. Clay, sand, marl, beds of shell, and hard rock were penetrated in this well. Hard rock is said to have been first struck in this well at 300 feet. Two other deep wells have been put down at Kingsland; but no satisfactory records of these wells have been obtained.

WOODBINE. — Two deep wells have been bored at Woodbine, both of which are two inches in diameter and 350 feet deep. Each well penetrated water-bearing strata at 250 feet and 350 feet. The water from the first stratum rises just to the surface; and, from the second stratum, it rises 40 or 50 feet above.

WHITE OAK. — (*Elevation, five feet above sea-level.*) The well of Mr. L. T. McKinnon was constructed in 1894, to obtain water for domestic purposes and to supply a turpentine distillery. It is four inches in diameter and 450 feet deep. The water is hard and sulphureted, and rises 50 feet above the surface. Two flows were struck in the well, one at 130 and the other at 450 feet. Limestone is reported to occur at 200 feet. Above the limestone, the drill is said to have penetrated sand, marl and clay with beds of oyster shells.

TARBORO. — The Safford Brothers own four wells at Tarboro, three, 8 inches in diameter, and one, 1 inch. These wells all attain a depth of 375 feet, and penetrate water-bearing strata at 175 and 375 feet. Water from the first water-bearing stratum rises six feet above the surface, and from the second stratum, 50 feet. The water, which is heavily charged with hydrogen sulphide, is used

for general domestic purposes, and also to operate a small rice mill, planer etc. Mr. Safford, one of the brothers, gives the following very meagre record of the wells:—

- | | | | |
|---|---|-------------|-------|
| 1 | Dark colored clays..... | to 100 feet | |
| 2 | Blue clay and marl interstratified with layers of limestone, from 2 to 10 feet. Bed of sand at 175 feet, first water-bearing stratum..... | | 340 " |
| 3 | Porous limestone with thin hard layers..... | | 375 " |
| 4 | Sand, second water-bearing stratum..... | | " |

The well of J. S. Bruce, located one and a half miles northeast of Tarboro, reaches a depth of 414 feet, and furnishes a flow, 50 feet above the surface. It is two inches in diameter, and supplies an abundance of hard, sulphureted water, which is used only for domestic purposes. The first flow is said to come from quicksand at 150 feet, and the second flow, from cavernous limestone near the bottom of the well.

A partial record of the well, furnished by Mr. Bruce, is as follows:—

- | | | |
|---|---------------------|------------|
| 1 | Surface sand | to 12 feet |
| 2 | Clay | " 24 " |
| 3 | Shell marl | " 29 " |
| 4 | Sand and clay | " 204 " |

Mr. W. C. Lang's well near Tarboro is said to be 345 feet deep. Its diameter is two inches, and the water rises 50 feet above the surface. Water-bearing strata are reported at 250 and 300 feet. A tough blue clay is said to have been penetrated in this well to a depth of 100 feet, below which limestone occurs. Between 200 and 300 feet from the surface, the drill is said to have dropped into two different cavities in the limestone, each having a depth of two or three feet.

Mr. J. B. Gadley's well at Tarboro, completed in 1902, has a depth of 350 feet. It is two inches in diameter and furnishes a flow having a static head of about 40 feet above the surface. A small flow was struck in this well at about 200 feet; but the main water-

supply comes from a porous limestone near the bottom of the well. The water is hard and sulphureted, and is used for general domestic purposes.

SATILLA BLUFF. — (*Elevation, 20 feet above sea-level.*) Two wells are reported at Satilla Bluff, one of which is owned by the Hilton and Dodge Lumber Company, and the other by J. F. Foster. These wells are two inches in diameter, and vary from 340 to 350 feet in depth. Water-bearing strata are reported in the Hilton and Dodge Lumber Company's well at 60, 210 and 340 feet; while, in the Foster well, water-bearing strata are said to occur only at 250 and 350 feet. The formations penetrated in these wells are said to be sands, clays and marls.

BAILEY'S MILL. — The well of Mr. L. M. Bedell, located at Burnt Fort, on the right bank of the Satilla river, near Bailey's mill, was put down in 1895. It is two inches in diameter and 200 feet deep, and it furnishes a strong flow; but the height, to which the water rises above the surface, was not ascertained.

A layer of rock one foot thick is reported to have been penetrated in this well at a depth of 12 feet from the surface, below which sand and clay, with an occasional thin layer of rock containing fossils, is said to continue to the bottom of the well. The water is strongly sulphureted, but wholesome.

OWEN'S FERRY. — Messrs. Dyal & Long's well was bored at Owen's Ferry in January, 1903, for the purpose of securing water for domestic and irrigation purposes. The well is two inches in diameter, and 370 feet deep. It furnishes a good supply of sulphureted water, which rises 25 feet above the surface. The main water-bearing stratum is said to be a rock near the bottom of the well.

WAVERLY. — The well of the Taylor & Cook Cypress Lumber Company is located one mile south of Waverly near the Seaboard Air Line Railroad. The well, which is two inches in diameter and 350 feet deep, was bored in 1896. The water is sulphureted, and it rises about 30 feet above the surface. The main water-supply

comes from near the bottom of the well. The casing extends 200 feet. The lower water-bearing stratum of Camden county appears to be Pliocene, though it may be Miocene or even Upper Eocene.

CALHOUN COUNTY

No report has been received from Calhoun county with regard to springs. They no doubt, however, occur in considerable number, as the county is underlain by the Eocene limestone, which is noted for its underground streams, lime sinks and large springs. The main source of domestic water-supply is obtained from shallow wells from the Columbia or Lafayette formations. Some of these wells also obtain water from the underlying Eocene beds; but the water of such wells is not generally regarded as wholesome. Especially is this true, if the water is obtained from what is known as "rotten limestone."

Deep wells have been constructed in Calhoun county at Arlington and Leary.

ARLINGTON. — The deep well at Arlington, which belongs to the town, is reported to have a depth of 625 feet. It is six inches in diameter, and the water rises to within 20 feet of the surface.

Dr. J. W. Spencer, formerly State Geologist of Georgia, gives the following record of the well:—

1	Chalky clay	20	feet
2	Sand and white clay.....(?)		"
3	Shell rock	5	"
4	Very coarse sand	(?)	"
5	Shell rock, etc.....to	355	"
6	Hard rock, siliceous, with soft places.....to	596 (?)	"
7	Hard, dark clay	500 (?)	"
8	Coarse, micaceous sand	540	"

Three water-bearing strata are reported in this well; but their depth from the surface is not given. There are two other deep wells at Arlington, one, a private well, and the other, owned by the Arlington Oil and Fertilizer Company. The latter well has a depth

of 328 feet. It is five inches in diameter, and it receives its water-supply about 300 feet from the surface.

LEARY. — The Leary deep well is two inches in diameter and 672 feet deep. The water rises 30 feet above the surface. Two or more water-bearing strata are reported in this well, above the one, which furnishes the flow; but their depths are not given. The capacity of the well is said to be about 20 gallons per minute. The water is used for steam and general domestic purposes, and is said to have a very beneficial effect upon the health of the inhabitants of the town.

The following record is given:—

1	Red clay	40	feet
2	Limestone	20	"
3	Blue clay	100 (?)	"
4	Hard rock	30	"
5	Quicksand	200 (?)	"
6	Hard rock containing shells.....	10	"

A well on Mr. J. E. Boyd's plantation, three miles north of Leary, is reported to have obtained a depth of 400 feet without furnishing a flow. No record of the well was preserved.

The upper water-bearing strata in the Arlington and Leary wells are Eocene, and the lower stratum is probably Upper Cretaceous or Lower Eocene.

CHATHAM COUNTY

The shallow wells of Chatham county, which are the chief source of domestic water-supply outside of the city limits of Savannah, may be said to vary from 15 to 40 feet in depth. The water of these wells is derived mainly from the superficial sands and clays, which are probably Pliocene, or even more recent deposits.

The springs of the county are of small size and few in number. The Jasper Spring, located near Savannah, is a spring of considerable historic interest; but it furnishes only a limited supply of water. Another spring, of like character, is the Sulphur spring at



PROVIDENCE SPRING, ANDERSONVILLE, SUMTER COUNTY, GEORGIA.



Thunderbolt, five miles southeast of Savannah. The geological conditions in Chatham county are very unfavorable for large springs; but, on the other hand, they are quite favorable for both shallow and deep wells. The latter class of wells, which are quite numerous in the city of Savannah and on Tybee Island, is also to be found at Bonaventure, Thunderbolt and Pooler.

SAVANNAH. — The second successful flowing well in Georgia was put down in Savannah by Capt. D. G. Purse, in 1885. This well had a depth of about 500 feet, and furnished a flow only 18 inches above the surface. The success of the well demonstrated, that there existed beneath the city a supply of artesian water; and, in a short time, three other wells were commenced and successfully completed. The city at present obtains its water-supply, amounting to something like eight millions of gallons daily, from 13 of these wells, 12 inches in diameter, and varying from 475 to 1,500 feet in depth. These wells are located about 100 feet apart, and are all connected with a common aqueduct leading to the pumping-station. Formerly, the natural flow of the wells was sufficient to supply the reservoir at the pumping station; but, in the last few years, the flow has been so reduced, that all the wells have now to be pumped in order to secure sufficient water for the city. It was supposed, at one time, that this decrease in flow was due to the filling of the casings with sand or other material; but it is now generally regarded as due chiefly to an overdraft on the water-bearing strata.

In addition to the wells, above described, the city has also 25 other wells at the old water-works. These wells vary from four to ten inches in diameter, and from 380 to 500 feet in depth. Besides the city wells, there are also a large number of private wells, making a total within the city limits of probably more than fifty.

The character of the water from the Savannah deep wells is shown by the following analysis, made by Dr. C. F. Chandler, of Columbia University, New York City, in 1886:—

Appearance in Two-foot Tube Clear; Colorless, Odorless and Tasteless.

<i>Constituents Determined</i>	Grains per U. S. Gallon
Chlorine in Chlorides.....	0.6192
Equivalent to Sodium Chloride.....	1.0218
Phosphates	trace
Nitrites	none
Nitrogen in Nitrates.....	0.0288
Free Ammonia	none
Albuminoid Ammonia	0.0017
Hardness, Equivalent to Carbonate of Lime before Boiling	4.0463
Hardness, Equivalent to Carbonate of Lime after Boiling	1.7804
Soda	0.7987
Potassa	0.1252
Lime.....	2.0344
Magnesia	0.7093
Oxide of Iron and Alumina.....	0.0233
Silica	3.1929
Sulphuric Acid	0.5160
Equivalent to Sulphate of Lime.....	0.8772
Organic and Volatile Matter.....	0.5832
Mineral Matter	12.8299
Total Solids at 110° C.....	13.4131

Biological Analysis: — 227 Colonies in 1 Cubic Centimeter.

The following field-analyses of the Savannah deep-well water, made by Mr. Burnham, December 15, 1904, was furnished by Mr. M. O. Leighton, Chief of the Division of Hydro-Economics, U. S. Geological Survey: —

<i>Constituents Determined</i>	Parts per Million	
	No. 1	No. 2
Chlorine	11.5	6.5
Total Carbonates as Calcium Carbonate.....	135.0	103.0
Scale-forming Carbonates as Calcium Carbonate.....	none	7.0
Alkali Carbonates as Sodium Carbonate.....	143.0	102.0
Total Hardness as Calcium Carbonate.....	138.0	110.0
Sulphur Trioxide	10.0	5.0
Iron	trace	trace

	Parts per Million	
	No. 1	No. 2
Color	none	none
Odor, Hydrogen Sulphide	1.0	3.0
Turbidity	none	none
Temperature, F. (estimated).....	78°	

Sample No. 1, from city well, 1,500 feet deep. Sample No. 2, from city wells, varying from 350 to 500 feet.

From a series of samples of well borings furnished by the Superintendent of the Savannah Water-works, the following notes have been made by the writer:—

- 1 Fine, sandy clay with a few fragments of fossiliferous limestone, more or less rounded by the motion of the water.....to 30 feet
- 2 Dark grayish green marl containing rounded pebbles and fragments of oyster shells with a few grains of glauconite " 50 "
- 3 The same as above..... " 60 "
- 4 The same as above..... " 70 "
- 5 Very tough, dark-colored clays with quartz pebbles and glauconite " 80 "
- 6 Brownish-colored clay containing dental plates of rays and minute rhombohedrons of calcite..... " 90 "
- 7 Greenish-gray clay, containing fragments of shells and shark's teeth " 100 "
- 8 The same as above; it also contains dental plates of rays " 120 "
- 9 Greenish-gray clay, frequently indurated..... " 130 "
- 10 The same as above..... " 160 "
- 11 Gray marl with round pebbles and glauconite. Microscopic examination shows the marl to consist largely of rhombohedral crystals of calcite..... " 180 "
- 12 Greenish-gray marl, containing waterworn pebbles of feldspar and quartz. Calcite crystals are also abundant " 190 "
- 13 The same as above..... " 200 "
- 14 The same as above..... " 210 "
- 15 Dark-gray clay with a few waterworn pebbles..... " 230 "
- 16 Dark-gray marl, containing fragments of corals, sea-urchins etc..... " 290 "

- | | | |
|----|---|-------------|
| 17 | White, porous, concretionary fossiliferous limestone, foraminifera, fragments of oyster shells, and spines of sea-urchins, common..... | to 320 feet |
| 18 | More or less compact gray limestone, containing fossils similar to those of the overlying beds; also, a few remains of gastropods..... | " 330 " |
| 19 | White, concretionary limestone with fossils similar to the above..... | " 400 " |
| 20 | Gray marl, often hardened into a porous rock containing fragments of oysters, pectens, crinoid stems, foraminifera, and small crystals of calcite. | " 410 " |
| 21 | The same as above, except that it contains fewer crinoid stems..... | " 413 " |
| 22 | Very white, chalky limestone, made up largely of coral | " 440 " |
| 23 | Gray coralline limestone, containing glauconite and many crinoid stems..... | " 450 " |
| 24 | The same as above; glauconite abundant..... | " 475 " |
| 25 | Dark greenish-gray marl, with glauconite filling casts of corals and foraminifera. The specimen also contains fragments of compact coralline limestone, which probably formed thin layers in the marl | " 510 " |

Specimens of fossils from these borings, obtained at 510 feet, were identified by Dr. W. H. Dall, as belonging to the Ocala horizon, which, according to his classification in Bulletin No. 84, U. S. Geological Survey, published in 1892, is Upper Eocene. The material from the surface to 120 feet was found to be mixed; however, he thought it was "perhaps Miocene." The number and depth of the different water-bearing strata in the Savannah wells are not given; but, judging from the depths of the wells, the first water-bearing stratum occurs between 300 and 400 feet from the surface.

TYBEE ISLAND. — The first deep well, constructed on Tybee Island, was put down by Capt. D. G. Purse, in 1885, shortly after the completion of the first deep well in Savannah. This well is two inches in diameter and 240 feet deep. The water rises 15 feet above the surface. Shortly after the completion of this well, two

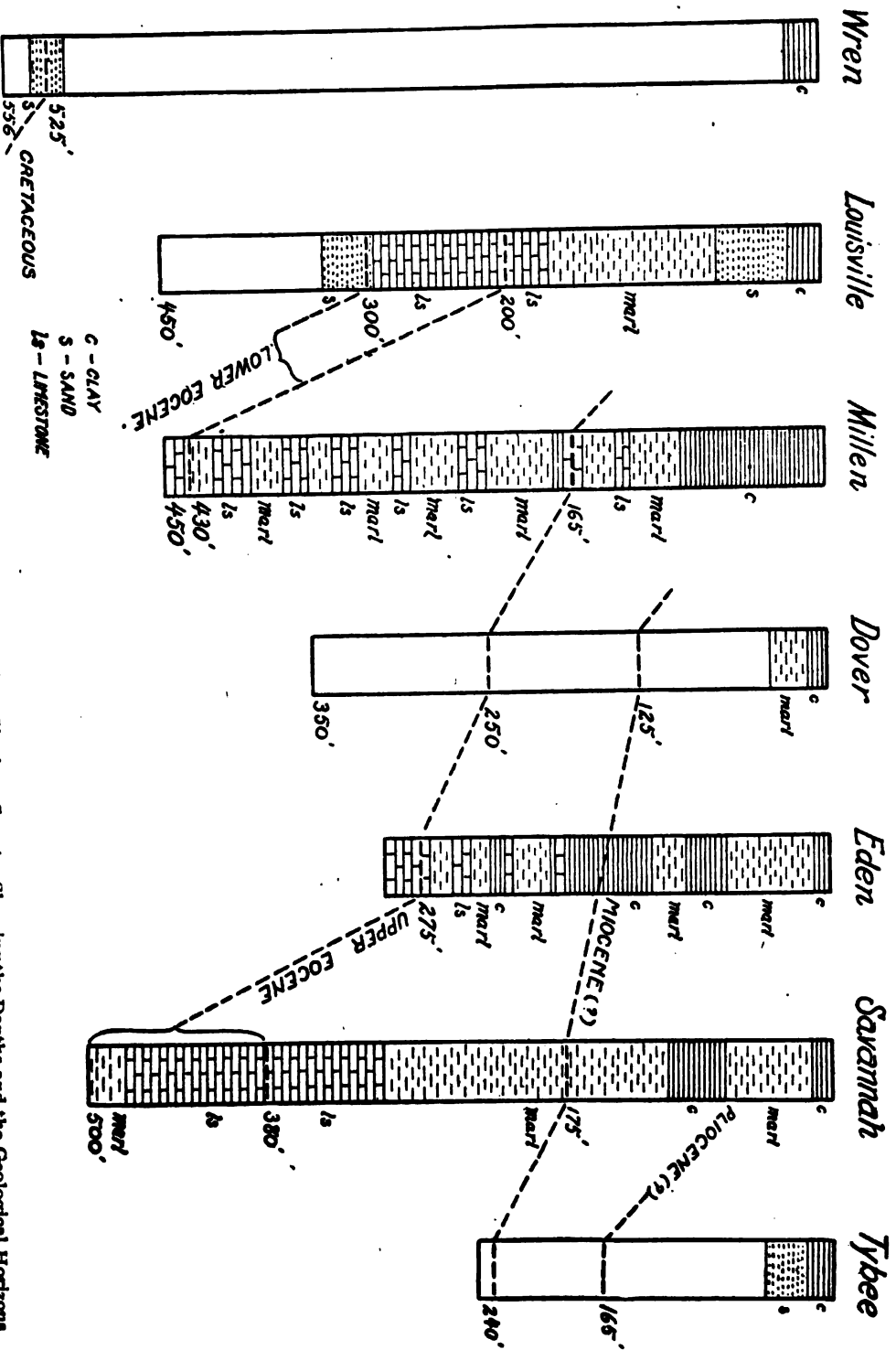


Fig. 2.—Sections of Deep Wells from Wren, Jefferson County, to Tybee, Chatham County, Showing the Depths and the Geological Horizons of the Main Water-bearing Strata.

others were bored, which attained about the same depth, and furnished a similar flow. One of these last named wells, which is located near the steamboat landing at the north end of the island, is said to be slightly affected by the tides. The water, which is used largely to supply the hotels and cottages on the island, is of excellent quality, for domestic purposes, as is shown by the following analysis by Dr. C. F. Chandler, Columbia University, New York City, 1886:—

Appearance in Two-foot Tube, Clear, Very Light Straw Color.
Odor, none. Taste, none.

<i>Constituents Determined</i>	Grains per U. S. Gallon of 231 cu. inches
Chlorine in Chlorides	0.7231
Chlorine, Equivalent to Sodium Chloride.....	1.920
Phosphates	trace
Nitrites	none
Nitrogen in Nitrates.....	0.0134
Free Ammonia	0.0026
Albuminoid Ammonia	0.0055
Hardness, Equivalent to Carbonate of Lime before boiling	5.6327
Hardness, Equivalent to Carbonate of Lime after boiling	3.7715
Soda	1.3464
Potassa	0.1844
Lime	1.8142
Magnesia	1.0322
Sesqui-oxide of Iron and Alumina.....	0.0233
Silica	3.4902
Sulphuric Acid	0.5691
Equivalent to Sulphate of Lime.....	0.9675
Organic and Volatile Matter.....	0.5832
Mineral Matter	6.4152
Total Solids at 110° C.....	6.9984

Analysis of water from Tybee Well made by Prof. H. C. White, of the University of Georgia, in 1885:—

Solid Matter Dissolved	Grains per U. S. Gallon
Carbonate of Lime	6.1328
Carbonate of Sodium	1.4411
Sulphate of Soda	2.1263
Sulphate of Lime	0.7542
Sulphate of Magnesia	0.0563
Carbonate of Iron.....	0.0180
Silicate of Soda.....	0.1232
Silica	0.0655
Organic Matter and Combined Water.....	0.1022
Total Solids Dissolved	10.8198

Nitrates, free and albuminoid ammonia practically none.

The following additional notes on the Tybee well, made by Mr. W. W. Burnham, has been furnished by Mr. M. O. Leighton, Chief of the Division of Hydro-Economics, U. S. Geological Survey:—

The Tybee Artesian, Ice, Water and Irrigation Company's well is located near the railroad, on Tybee Island, about 13 feet above sea-level. The well is three inches in diameter, 158 feet deep, and barely furnishes a flow during low tide. The water from this well, which is sulphureted, is used for boiler, irrigation and general domestic purposes.

The Fort Screven well, put down in July, 1902, near the center of the reservation owned by the United States War Department, is six inches in diameter and 156 feet deep. It flows about 42 gallons per minute; but, like some of the other wells on the island, it is affected more or less by the tides. The water is used to supply Fort Screven. The field-analysis of the water from this well, made by Mr. Burnham, is as follows:—

<i>Constituents Determined</i>	Parts per Million
Chlorine	6.5
Total Carbonates as Calcium Carbonate.....	103.0
Scale-forming Carbonates as Calcium Carbonate	12.0
Alkali Carbonates as Sodium Carbonate.....	96.5
Total Hardness as Calcium Carbonate.....	124.0
Sulphur Trioxide	5.0 (estimated)
Iron	0.5 (estimated)

	Parts per Million
Odor, Hydrogen Sulphide	2.0
Color	none
Turbidity	"
Temperature, F. (estimated)	68°

Another well, on the Fort Screven reservation near Tybee railroad, is one inch in diameter and 80 feet deep, and flows from 10 to 30 gallons a minute. The field-analysis of the water from this well, by Mr. Burnham, is here given:—

<i>Constituents Determined</i>	Parts per Million
Chlorine	9.0
Total Carbonates as Calcium Carbonate.....	107.0
Scale-forming Carbonates as Calcium Carbonate	—
Alkali Carbonates as Sodium Carbonate.....	—
Total Hardness as Calcium Carbonate.....	124.0
Sulphur Trioxide	5.0 (estimated)
Iron	0.5 "
Odor, Hydrogen Sulphide	2.0
Color	none
Turbidity	"
Temperature, F. (estimated)	68°

Mr. Burnham reports 15 wells upon Tybee Island; but he was unable to secure any data concerning the formations penetrated in any of these wells. The lower water-bearing strata of the deeper wells of the island are probably Miocene, and the Upper Pliocene.

POOLER. — Mr. Burnham reports four wells at Pooler; but he was unable to secure any data, whatever, concerning them. A sample of the water, taken from Mr. E. H. Newton's well at this place, was analyzed by Mr. Burnham with the following results:—

<i>Constituents Determined</i>	Parts per Million
Chlorine	6.5
Total Carbonates as Calcium Carbonate.....	105.0
Scale-forming Carbonates as Calcium Carbonate	0.0
Alkali Carbonates as Sodium Carbonate.....	112.0
Total Hardness as Calcium Carbonate.....	110.0
Sulphur Trioxide	5.0 (estimated)
Iron	trace



A LIME-SINK, SHOWING AN UNDERGROUND STREAM, NEAR MULLEN, BURKE COUNTY, GEORGIA.



	Parts per million
Odor, Hydrogen Sulphide	4.0
Color	none
Turbidity	"
Temperature, F.....	78°

CHATTAHOOCHEE COUNTY

Chattahoochee county has only one deep well. It is located on Mr. W. C. Bradley's plantation, in the western part of the county. The well, which was put down in 1897, is reported by Mr. Bradley to have a depth of 700 feet. It is four inches in diameter, and the water comes to within 90 feet of the surface. The well is said to have a capacity of about 600 gallons per hour. The water is used for general domestic purposes.

The formations passed through, in boring the well are reported to consist of clay, sand and marl, no hard rock having been encountered. One water-bearing stratum occurs at 285 feet; the depths of the others are not given. The well penetrates the Cretaceous for its entire depth.

The domestic water-supply of Chattahoochee county is obtained largely from shallow wells. No springs of large size are reported. The county is underlain wholly by the Cretaceous deposits, which are usually unfavorable for springs of large size.

CLAY COUNTY

The only deep well, so far put down in Clay county, is at Fort Gaines, the county-seat. The well, which has a depth of 650 feet, was constructed in 1885 by the town of Fort Gaines, at a cost of about \$2,000. The diameter of the well varies from three to four inches. The water rises to within 20 feet of the surface. Dr. J. W. Spencer, in speaking of the Fort Gaines well, says:¹ "The record of this well is lost; but it reaches a depth of 650 feet. The lower 350 or 400 feet of these strata belong to the Ripley, or Upper Cretaceous, system, which is overlain by the impervious beds of the Lower Eocene limestones."

¹ First Report of Progress, Geological Survey of Georgia, p. 79, 1891.

The water from the Fort Gaines well is said to be very wholesome. The following is an analysis of the water, made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	16.10	.939
Sulphur Trioxide	7.84	.430
Carbon Dioxide	118.80	5.930
Phosphorus Pentoxide	4.75	.277
Chlorine	20.40	1.190
Iron Sesqui-oxide and Alumina.....	3.56	.208
Lime	9.94	.580
Magnesia	2.31	.135
Potash	10.94	.638
Soda	102.70	5.989
<i>Probable Combination</i>		
Potassium Chloride	17.22	1.004
Sodium Chloride	20.00	1.166
Sodium Sulphate	14.68	.856
Sodium Phosphate	6.88	.401
Sodium Carbonate	146.50	8.544
Magnesium Carbonate	4.85	.283
Calcium Carbonate	17.75	1.040
Total Solids	247.54	14.435
Free Carbon Dioxide	47.65	2.779

As all the southern portion of Clay county is underlain by Eocene beds, springs, of considerable size, are probably of common occurrence throughout that section; though their location and ownership have not been reported. Shallow wells, varying from 15 to 60 feet in depth, are the main source of the domestic water-supply. In the absence, or in the thinning of the Columbia and the Lafayette sands and clays, these wells obtain their water-supply from the underlying Cretaceous and Eocene beds.

COFFEE COUNTY.

The only spring, of any importance, reported in Coffee county,

is the Gaskins Spring, located on the edge of a swamp near Seventeen-mile Creek, about two miles east of Douglas. The spring has a moderate flow. Its water is used for general domestic purposes and for bathing, a bath-house being located near the spring. The main water-supply in the county, for general purposes, is obtained from shallow wells.

The only deep well reported in the county is at Douglas, the county-seat. This well, which belongs to the Douglas Ice and Power Company, was completed in August, 1902. It is a six-inch well, 409 feet in depth. Water-bearing strata are reported at 325 and 390 feet. The static head of the first stratum is said to be 130 feet below the surface, and the second, 170 (?) feet. The record of the well, furnished by the Company, shows that clays and sands were penetrated to a depth of 130 feet, below which sand and hard rock continue to the bottom. The analysis of the water from the Douglas deep well, made by Dr. Edgar Everhart, in the laboratory of the Geological Survey of Georgia, is as follows:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	83.43	4.865
Sulphur Trioxide	2.16	.130
Carbon Dioxide	156.40	9.120
Phosphorus Pentoxide	1.50	.087
Chlorine	10.20	.595
Iron Sesqui-oxide and Alumina	33.81	1.972
Lime	48.31	2.817
Magnesia	11.75	.685
Potash	5.56	.324
Soda	15.75	.918
<i>Probable Combination</i>		
Potassium Chloride	8.81	.514
Sodium Chloride	9.90	.577
Sodium Sulphate	3.83	.224
Sodium Phosphate	2.17	.127
Sodium Carbonate	13.49	.787
Magnesium Carbonate	24.68	1.439
Calcium Carbonate	86.27	5.031
Total Solids	266.39	15.535
Free Carbon Dioxide	99.92	5.432

The water-bearing strata in the Douglas deep well are probably Eocene; while the water-supply of the shallow wells is obtained from the Columbia and Lafayette sands and clays and the underlying Miocene beds.

COLQUITT COUNTY

The shallow wells of Colquitt county vary from 15 to 50 feet in depth. They obtain their water-supply chiefly from the Lafayette formation; though, in some instances, they no doubt enter the underlying Miocene beds. This class of wells appears to be the main reliance for the domestic water-supply. The springs of the county seem to be few in number and of little importance.

MOULTRIE, the county-seat of Colquitt county, is supplied, at present, with water from deep wells. There are two of these wells, one of which was bored in 1897, and the other in 1902. The well, put down in 1897, is six inches in diameter and 571 feet deep; and the one, put down in 1902, is eight inches in diameter and 506 feet deep. The water in these wells rises to within 240 feet of the surface. The only water-bearing stratum reported in the wells is 486 feet from the surface.

An analysis of the water, made by Dr. Edgar Everhart, Chemist, of the Geological Survey of Georgia, is as follows:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	23.44	1.367
Sulphur Trioxide	10.33	.600
Carbon Dioxide	142.00	8.280
Phosphorus Pentoxide	trace	trace
Chlorine	9.52	.554
Iron Sesqui-oxide and Alumina.....	6.17	.359
Lime	24.60	1.435
Magnesia	12.28	.716
Potash	13.24	.772
Soda	31.94	1.863

<i>Probable Combination</i>	Parts per Million	Grains per U. S. Gallon
Potassium Chloride	20.00	1.166
Potassium Sulphate	1.18	.069
Sodium Sulphate	17.37	1.013
Sodium Phosphate	trace	trace
Sodium Carbonate	41.65	2.429
Magnesium Carbonate	25.79	1.498
Calcium Carbonate	43.93	2.562
Total Solids	159.53	9.302
Free Carbon Dioxide.....	91.87	5.358

The water-bearing stratum of the Moultrie deep wells is probably Upper Eocene.

CHAPTER VII

DETAILED DESCRIPTION OF THE UNDERGROUND WATERS OF THE COASTAL PLAIN BY COUNTIES (Continued)

DECATUR COUNTY

Decatur county has several large springs, only two of which have been visited by the writer. One of the springs, here referred to, is located in the southwestern part of the county, near the mouth of Spring Creek, about 20 miles south of Bainbridge. This spring, which furnishes several millions of gallons of water per day, is in the form of a nearly circular basin, many rods in circumference and from 10 to 30 feet deep. It is noted for the transparency of its waters and its large flow. The other spring, referred to, is near the left bank of the Flint River, about five miles south of Bainbridge. This spring, like the one near the mouth of Spring Creek, is also in the form of a basin; and it likewise furnishes a large volume of water. So remarkably transparent is the water of these springs, that, when on them in a boat, one feels as though the boat were suspended in mid-air. Fish, at a depth of 15 feet or more, are distinctly seen, and their specific markings can be studied almost as perfectly, as if they were in an aquarium. The transparency of the water of these springs would seem to indicate, that they come up from considerable depth, and have no direct surface connection with the numerous limesinks often met with throughout the county.

In addition to the large springs of Decatur county, it is also fairly well supplied with small springs, which furnish ample water for domestic purposes. The water of some of these small springs

carries iron, hydrogen sulphide, etc., and is regarded locally as possessing medicinal properties of value.

Decatur county, owing to its being underlain by rather porous Eocene limestone, is noted for its many limesinks and underground streams. A good example of these subterranean streams may be seen at what is known as Forest Falls, seven miles north of Whigham. At this place, a brook of sufficient size to run a mill, disappears underground in a limesink, after a perpendicular descent of 80 feet. A few miles further to the north, at what is called the "Water Falls," a second stream disappears underground in like manner. At the bottom of some of the deeper limesinks, east of the Flint River, are occasionally seen rapidly flowing underground streams. More generally, however, the sinks are partially filled with water, and form beautiful ponds, well stocked with fish. During the dry season many of these ponds are drawn off by the underground streams, with which they seem to be invariably connected.

The domestic water-supply of Decatur county is largely obtained from shallow wells, which vary in depth from 15 to 60 feet. The water of these wells is usually soft, when obtained from the Lafayette or Columbia formations; but, when it comes from the underlying Eocene or Miocene beds, it is frequently hard. The deep wells of the county are at Bainbridge and Donaldsonville.¹

DONALDSONVILLE. — There are several deep wells in the vicinity of Donaldsonville; but no satisfactory record has been received from any of them. The following notes are made from samples of one of these wells, furnished by Messrs. J. C. Cole & Co.; well contractors: —

- | | | |
|---|--|---------|
| 1 | Vari-colored sands and clays.....to | 45 feet |
| 2 | Sand and limestone, the latter made up largely of nummulites | " 50 " |
| 3 | Fine white sand and clay..... | " 140 " |

The character of the water, obtained from the Donaldsonville deep wells, is shown by the following analysis by Prof. H. C. White, of the University of Georgia, kindly furnished by the Chattahoochee Lumber Company: —

¹ Since the above was written deep wells have been put down at Whigham and Cairo in Grady County, formerly a part of Decatur County.

<i>Constituents Determined</i>	<i>Grains per U. S. Gallon</i>
Chlorine	0.5320
Equivalent to Sodium Chloride.....	0.8778
Lime	2.1433
Magnesia	0.6124
Soda	0.6517
Potassa	0.0962
Sesqui-oxide of Iron and Alumina.....	0.0146
Silica	2.2335
Sulphuric Anhydride	0.5421
Phosphates	none
Nitrites	none
Nitrogen in Nitrates	0.0136
Free Ammonia	none
Albuminoid Ammonia	0.0012
Hardness before boiling equivalent to Carbonate of Lime	4.1232
Hardness after boiling equivalent to Carbonate of Lime	1.9025

BAINBRIDGE. — (*Elevation, 118 feet above sea-level.*) Two wells have been sunk at Bainbridge, one of which is reported to be 900 feet in depth and the other 1,325 feet. Three different water-bearing strata are reported in each of these wells. The first stratum occurs at 280 feet, and the second at 370 feet from the surface. Both of these, which are said to be cavernous limestone, yield a good supply of water, which rises to within 50 feet of the surface. The third water-bearing stratum is reported to be a quicksand below the limestone; but the depth is not given.

Dr. J. W. Spencer, formerly State Geologist of Georgia, makes the following notes on the Bainbridge well:¹—

- "1 Sand and clayey sand..... 75 feet
- 2 Limestone (the upper 200 feet the softer); no clay
layers.....700 "
- 3 Soft Limestone
- 4 Quicksand to bottom of well..... 50 "
- 75 "

"A second well was sunk within three feet of the first, which penetrated below the limestone to a depth of 425 feet in quicksand. Sharks' teeth, lignite and pyrite concretions came from some of the

¹ First Report of Progress, Geological Survey of Georgia, p. 55, 1891.

layers of sand. Several cavities in the limestone were passed through, the deepest being three feet."

The following analysis of the water, made by Prof. H. C. White, of the University of Georgia, has been furnished by the town authorities:—

Water from the First Well

Solid Matter in Suspension	Grains per U. S. Gallon
Iron Sesqui-oxide	0.791
Organic Matter	1.150
Total	1.941
Solid Matter Dissolved	
Carbonate of Lime.....	8.215
Sulphate of Soda.....	2.222
Sodium Chloride	2.065
Sulphate of Lime	1.156
Sulphate of Magnesia.....	1.323
Silica	0.229
Organic Matter Undetermined	0.012
Total.....	15.222

Water from the Second Well

Solid Matter Dissolved	Grains per U. S. Gallon
Carbonate of Lime.....	3.6146
Carbonate of Soda	4.6521
Sodium Chloride	1.6543
Sulphate of Soda	1.8562
Sulphate of Lime	0.7543
Sulphate of Magnesia.....	0.0424
Carbonate of Iron	0.0114
Silicate of Soda.....	0.1013
Silica.....	0.1875
Organic Matter and Water.....	0.0556
Total.....	12.9297
Free Ammonia	none
Albuminoid Ammonia.....	trace

The water-supply of the Bainbridge and Donaldsonville deep wells appears to be obtained from the Vicksburg-Jackson limestone.

DODGE COUNTY

Two deep wells are reported in Dodge county, neither of which furnishes a flow. One of these wells is at Eastman, the county-seat, and the other, at Chauncey, a station on the Southern Railway, several miles further to the southeast. They both probably obtain their water-supply from Eocene limestone.

EASTMAN. — (*Elevation, 357 feet above sea-level.*) The well at Eastman is 529 feet deep. Its diameter is 4 and 6 inches, and the water rises to within 115 feet of the surface. Two or three different water-bearing strata are reported in the well; but the present water-supply is said to be obtained from sand 529 feet from the surface. No record of the well-borings was kept, and nothing is known of the formations penetrated, further than that they consist of sand, clay and hard rock, the latter being most abundant, and in places consisting largely of boulders, which greatly interfered with the drilling. The well, which was put down in 1894, furnishes daily, to supply the town of Eastman, about 30,000 gallons of water.

Dr. George F. Payne, formerly State Chemist, furnishes the following partial chemical analysis of a sample of water from the Eastman well:—

Total Solids per U. S. Gallon.....	15.16	grains
Chlorine .....	.23	"
Free Ammonia in Parts per Million.....	.004	
Albuminoids " " " " .....	.02	

CHAUNCEY. — (*Elevation, 300 feet above sea-level.*) The Chauncey well, owned by the A. B. Steele Lumber Company, is six inches in diameter and 525 feet deep. The water rises to within 70 feet of the surface. Mr. R. J. Ederfeld, the well contractor, reports only one water-bearing stratum at 300 feet. The record of the borings from this well showed, that it penetrated beds of sand, clay and limestone, with an occasional layer of flint, one of which attains a thickness of more than 10 feet.

Dodge county lies wholly within the Eocene area; and it probably has numerous large springs; though no information is at hand

concerning their location. Nearly every farm-house is said to be supplied with water for drinking and domestic purposes from shallow wells, which penetrate the Lafayette or the underlying Eocene deposits. The water from these wells is usually quite wholesome and free from mineral impurities.

DOOLY COUNTY

This county has been quite extensively explored for water by deep borings, which have, in all cases, been successful in obtaining large quantities of water. In many instances, these wells are flowing. Especially is this true of those located near Coney, in the western part of the county. The water-bearing strata in all the wells appear to be Eocene. A sea-urchin, brought up from one of the Cordele wells, at 225 feet, has been identified by Dr. Dall as belonging to Ologocene; but the exact horizon is not given.

CORDELE. — (*Elevation, 336 feet above sea-level.*) The first deep well at Cordele was put down by the town council in 1890, at a cost of about \$1,000. The water of this well, which is said to be 550 feet deep, rises to within 20 feet of the surface. Mr. E. R. Hathaway gives the following record of this well:—

1	Soil, clay and "chalk".....	40 feet
2	Coarse red sand to.....	60 "
3	Loose boulder rock, through which the tubing was driven (fine white sand was also found) to.....	68 "
4	Different colored marls (clays or true marls (?)) to...	168 "
5	Limestone and shell rock, with an intervening layer of sand, to	400 "
6	Sand and shell rock to.....	475 "
7	Quicksand to	535 "

The water, which contains hydrogen sulphide, comes from the quicksands below the limestone. This is the only water-bearing stratum reported in the well. At a depth of between 200 and 300 feet from the surface, a cypress log, about two feet in diameter, is said to have been penetrated by the drill.

A second well, sunk by the town of Cordele in 1900, is eight

inches in diameter and 400 feet deep, and furnishes daily about 300,000 gallons of water. The following analysis of the water from this well was made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	11.45	.668
Sulphur Trioxide	3.68	.215
Carbon Dioxide	99.32	5.792
Phosphorus Pentoxide	trace	trace
Chlorine	5.60	.327
Iron Sesqui-oxide and Alumina.....	2.94	.171
Lime	61.38	3.580
Magnesia	1.85	.108
Potash	1.73	.101
Soda	4.27	.249
<i>Probable Combination</i>		
Potassium Chloride	2.74	.160
Sodium Chloride	7.08	.413
Sodium Sulphate	1.16	.068
Sodium Phosphate	trace	trace
Magnesium Sulphate	5.55	.324
Calcium Sulphate	0.23	.013
Calcium Carbonate	109.45	6.383
Total Solids	140.60	8.200
Free Carbon Dioxide	51.16	2.984

CONEY. — The well of Mr. S. W. Coney, put down in 1896, to supply water for domestic purposes, is six inches in diameter and 278 feet deep. The water rises three feet above the surface, the flow being about 15 gallons per minute. There are two other wells at Coney, one of which is owned by Mr. J. B. Lewis, and the other by Mr. J. M. Campbell. The former well has a depth of 360 feet, and is said to have struck water-bearing strata at depths of 150, 225 and 340 feet. The water of this well rises to within six feet of the surface. The Campbell well is only 285 feet deep, and is reported to have penetrated several water-bearing strata, the last of which

is near the bottom of the well, and furnishes a flow four feet above the surface. The contractor of the Campbell well has furnished the following record:—

1	Yellow clay to.....	20	feet
2	Soft limestone to.....	45	"
3	Hard, compact limestone to.....	51	"
4	Limestone containing shells to.....	91	"
5	Blue clay to.....	136	"
6	Hard, compact limestone to.....	144	"
7	Blue clay to.....	180	"
8	Limestone with shells to.....	200	"
9	Marl and coarse sand to bottom of well		

The well of Daniel Wells is located three miles west of Coney, and has the following record, furnished by the well contractor from memory:—

1	Yellow clay to.....	12	feet
2	Limestone to	40	"
3	Subterranean cavity to.....	48	"
4	Limestone to	56	"
5	Pebbles to	61	"
6	Clay to	89	"
7	Limestone to	91	"
8	Bluish clay to.....	131	"
9	Limestone to	145	"
10	Dark-colored sand, with shells and sharks' teeth, to.....	216	"
11	Flint to	217½	"
12	Dark colored sand to.....	220½	"
13	Limestone to	(?)	

This well is three inches in diameter and 336 feet deep. A number of water-bearing strata are reported in the well; but none furnished a flow, except the one struck at 336 feet, from which water rises five feet above the surface.

Mr. P. C. Clegg's well, six miles west of Coney, has a depth of 216 feet. It is four inches in diameter, and flows about six gallons per minute. The record of the well is as follows:—

1	Gray, sandy clay to.....	15	feet
2	Blue clay to.....	96	"
3	Limestone to	108	"
4	Coarse sand to.....	123	"
5	Fossiliferous limestone to.....	143	"
6	Blue clay to.....	193	"
7	Shell rock and coral to.....	209	"
8	Flint, in thin layers of limestone to bottom of the well		

Water-bearing strata are reported in this well at depths of 60, 96 and 200 feet; but no flow was secured, until the drill entered the limestone near the bottom of the well. This furnishes an abundant supply of water, rising four feet above the surface.

The well of Mr. James Byrom, which is located near the Flint River, a few miles northwest of Coney, is said to have penetrated the following strata:—

1	Yellow clay to.....	54	feet
2	Limestone to	82	"
3	Cavity to	90	"
4	Limestone to	100	"
5	Cavity to	114	"
6	Bluish clay to.....	154	"
7	Dark-colored sand to.....	254	"
8	Limestone to	260	"
9	Cavity to	265	"
10	Limestone to	272	"
11	Flint to	274	"
12	Fine white sand to.....	302	"
13	Flint to	304	"
14	Dark-colored sand and pebbles.....	(?)	

The Byrom well is two inches in diameter and 360 feet deep, and furnishes a flow eight feet above the surface. Five different water-bearing strata are reported in the well, but their depths are not given.

Richwood.— (*Elevation, 358 feet above sea-level.*) The Parrott Lumber Company, some years ago, put down two deep wells at Richwood, to obtain water for steam and general domestic purposes. These wells are six inches in diameter and 170 feet deep. The first water-bearing stratum is said to have been struck in the

wells at a depth of 85 or 95 feet from the surface; but the main water-supply was obtained from a stratum at a depth of from 130 to 170 feet, from which the water rose to within 40 feet of surface. During the time the Parrott Lumber Company was operating its plant at Richwood, these wells are reported to have furnished about 75,000 gallons of water daily. Long droughts are said not to have materially lowered the static head of the water in either of these wells. Hard rock is reported from 60 feet to the bottom of the wells.

A third well at Richwood, belonging to Mr. H. R. Teal, has a depth of 100 feet. It is four inches in diameter, and the water rises to within about 35 feet of the surface. Mr. Teal gives the following record of his well:—

Clay with some sand.....	to	90 feet
Limestone.....	"	96 "
Sand, water-bearing.....	"	100 "

UNADILLA. — (*Elevation, 412 feet above sea-level.*) The deep well at Unadilla was completed in 1896. It is three and a half inches in diameter and 189 feet deep. The water rises to within 80 feet of the surface. Mr. E. J. Wilson, the well contractor, has furnished the following notes:—

1	Red sandy clays to.....	50 feet
2	Rock in the form of boulders.....	66 "
3	Clay to	150 "
4	Sand interstratified with hard rock to.....	189 "

At the depth of 150 feet from the surface, the water used in washing out the drill borings disappeared. This was accounted for, by the cavernous limestone, struck at that point. The only water-bearing stratum occurs near the bottom of the well. Three thousand gallons of water per hour, the capacity of the pump, have been obtained from this well without lowering the static head. The water, which contains hydrogen sulphide, is used for general domestic purposes.

PENIA. — (*Elevation, 375 feet above sea-level.*) The Penia deep well is four inches in diameter and 320 feet in depth. The water is said to rise within 120 feet of the surface. No record of the well has been obtained.

FENN. — The deep well at Fenn, owned by the Ensign Lumber Company, was completed in 1891 at a cost, including pump, casing, etc., of about \$1,000. It is an eight-inch well, 160 feet deep. The water rises to within 20 feet of the surface, at which point it is said to remain throughout the year. The strata penetrated are not reported.

VIENNA. — (*Elevation, 319 feet above sea-level.*) The well at Vienna, the county-seat of Dooly county, has a depth of 180 feet. The water, which is used for general domestic purposes and for irrigation, rises to within 12 feet of the surface. The well furnishes 150 gallons per minute, the capacity of the pump. Hard rock is reported to have been penetrated; but its depth from the surface is not given.

BYROMVILLE. — The Byromville deep well, put down by the town authorities, is two and six inches in diameter and 1,100 feet deep. The water rises to within 17½ feet of the surface, or 347 feet (?) above sea-level.

Mr. W. H. Byrom furnishes the following record:—

1	Sand clay	to	40 feet
2	Red gravel	"	50 "
3	White sand	"	110 "
4	Coarse sand	"	133 "
5	Blue marl	"	158 "
6	Sand	"	195 "
7	Rock	"	210 "
8	Marl	"	213 "
9	Sand rock	"	218 "
10	Blue marl	"	223 "
11	Sand.....	"	227 "
12	Hard rock	"	230 "
13	Sand.....	"	415 "
14	Rock	"	438 "
15	Sand rock	"	450 "



WADE'S SPRING, NEAR QUITMAN, BROOKS COUNTY, GEORGIA.



16	Marl and clay	to	454	feet
17	Blue marl	"	614	"
18	Sand and marl	"	630	"
19	Lignite and water	"	645	"
20	Marl and sand	"	849	"
21	Hard sand	"	919	"
22	Sand and water	"	934	"
23	Marl.....	"	1,010	"
24	Sand.....	"	1,047	"
25	Marl.....	"	1,100	"

PINEHURST. — The public well at this place has a depth of 318 feet. The water rises to within eight feet of the surface, and is said to be of excellent quality. No record of the well has been secured.

ARABI. — (*Elevation, 399 feet above sea-level.*) Mr. R. A. Bedgood's well at Arabi, sunk in 1890, is six inches in diameter and 298 feet deep. This is a non-flowing well; but the height to which the water rises is not given. Successful deep wells have also been put down in Dooly county at Ada and Sibley; but no satisfactory information has been secured concerning their records.

There are several large springs in Dooly county, one of which may be seen near the corporate limits of Cordele. This spring, which furnishes several hundred thousand gallons per day, formerly supplied the town with water. It is located on the bank of Gum Creek, and is protected from overflows by a stone wall. The water is clear, and, though hard, appears to be of good quality.

DOUGHERTY COUNTY

Dougherty county has a large number of deep wells, nearly a score of which are located in Albany, the county-seat. So numerous are these wells in Albany, that it is frequently spoken of as the "Artesian City."

ALBANY. — (*Elevation, 172 feet above sea-level.*) The Albany wells vary in depth from 300 to 1,320 feet. The deeper wells penetrate two or more water-bearing strata, the lowest of which furnish water rising 30 feet above the surface. Mr. Charles Tift, formerly

Superintendent of the City water-works, and who has made quite a study of the deep wells of Albany, states that the first water-bearing stratum in these wells was struck at about 300 feet from the surface, the second, at 660 feet, and the third, at 1,320 feet. Only the second and the third strata furnish a flow. The following log of one of the Albany deep wells has been furnished by Mr. Tift, to which is added the notes of Dr. Wayland Vaughan, of the U. S. Geological Survey, on the geological horizons:—

CITY ARTESIAN WELL, No. 2

Bored by Mr. E. F. Joyce	Log by Mr. C. W. Tift		
Red clay	from	0 to	20 ft.
Light-colored clay	"	20 "	23 "
Coarse sand (Vicksburg)	"	23 "	25 "
Light-colored clay and coarse quartz sand...	"	25 "	35 "
Limestone, <i>orbitoides</i> , at 150 feet, and from 190 to 200 feet	"	35 "	200 "
Gray limestone, <i>orbitoides</i> , <i>echinoid</i> , <i>bryozoa</i> , <i>terebratula</i> ; some shale from 230 to 240 feet	"	200 "	280 "
Gray sand with comminuted shells (<i>ostrea</i>) ..	"	280 "	285 "
Some shale, coarse sand, shells and sharks' teeth at	"		311 "
Hard layer, <i>ostrea divaricata</i>	"	318 "	320 "
<i>Ostrea divaricata</i> at			330 "
<i>Ostrea alabamiensis</i> at			340 "
Shale or marl, water vein at			350 "
<i>Ostrea divaricata</i> and <i>alabamiensis</i> at			363 "
Bed of lignite at			367 "
Bed of lignite at			400 "
Sand	"	400 "	475 "
<i>Echinoid spines</i> , <i>lamna teeth</i> , stiff blue clay ..	"	470 "	475 "
Stiff blue clay	"	475 "	480 "
Hard gray sandstone	"	485 "	488 "
Eocene from the surface to			500 "
Pyrite and small oysters at			520 "
Green sands and greenish micaceous shales ..	"	530 "	540 "
Gray sand with black particles at			600 "
Water-bearing horizon, limestone, with pieces of hard gray sandstone between 785 and 790	"	690 "	790 "

Hard rock	from 790 to 800 ft.
Clay shales, white limestone between 835 and 840	" 800 " 850 "
Limestone and shales.....	" 850 " 890 "
Chiefly sand, at top a little gravel. At 880 feet limestone or calcereous sand, also light gray micaceous sand; at 890 feet, grayish sand, calcareous fragments, hard, black pieces of pebbles and <i>ostrea</i> , water-bearing micaceous sandstone between 920 and 930 feet.....	" 890 " 940 "
Blue micaceous clay at 950 feet, thick shelled oyster, <i>gryphaea</i> , the same also at 1,080 feet; at 1,100 feet gray sand with <i>ostrea</i> , <i>exogyra costata</i>	" 940 " 1,100 "
Stiff blue clay, micaceous sandstone, oysters..	" 1,100 " 1,200 "
Very stiff blue clay, at 1,255 feet, streaks of sand and shells, a small flow of water; from 1,240 to 1,260 soft shiny blue clay.....	" 1,200 " 1,260 "
Marl, gray sand, sandstone lumps, shells....	" 1,260 " 1,270 "
Gray and black sand, sandstone lumps.....	" 1,270 " 1,310 "
Black irregular, waterworn pebble, with hard crystalline fracture; coarse and fine quartz sand, shells, decayed wood, third water-bearing stratum; 50 gallons per minute...	" 1,310 " 1,315 "
Well ends in quartz sand at.....	1,320 "
Temperature of water 78° F.	

The water from the second water-bearing stratum, which furnishes the main supply to the city, has a distinct odor of hydrogen sulphide. An analysis of it, made by Prof. H. C. White, of the University of Georgia, is here given:—

Constituents Determined	Grains per U. S. Gallon
Calcium Carbonate	6.275
Magnesium Carbonate .....	.384
Calcium Sulphate .....	.583
Sodium Chloride .....	.351
Iron Sesqui-oxide and Alumina.....	.153
Silica .....	.545
Organic Matter .....	.414
Undetermined, etc.....	.640
Total	9.345

<i>Sanitary Analysis</i>	Parts per Million
Total Solids	160.254
Organic Carbon .....	.096
Organic Nitrogen .....	.001
Nitrogen in Ammonia and Nitrites.....	none
Nitrogen in Nitrates.....	.045
Total Combined Nitrogen .....	.046
Chlorine	3.652
Equivalent to Na Cl.....	6.024
Hardness, temporary	2.10
Hardness, permanent	4.40
Total	6.50

Analysis of water from the third water-bearing stratum, made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia, is as follows:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	13.62	.794
Sulphur Trioxide	1.22	.070
Carbon Dioxide	677.00	39.480
Phosphorus Pentoxide	trace	trace
Chlorine	69.36	4.045
Iron Sesqui-oxide and Alumina.....	1.75	.102
Lime	6.00	.350
Magnesia	3.00	.175
Potash	34.72	2.024
Soda	623.76	36.376
<i>Probable Combinations</i>		
Potassium Chloride	55.03	3.209
Sodium Chloride	71.09	4.146
Sodium Sulphate	2.16	.126
Sodium Phosphate	trace	trace
Sodium Carbonate	998.71	58.243
Magnesium Carbonate	6.30	.367
Calcium Carbonate	10.71	.625
Total Solids	1159.37	67.611
Free Carbon Dioxide	254.43	14.838
Hardness, permanent .....	.44	
Hardness, temporary .....	.45	
Total .....	.89	

There is quite a remarkable difference in the chemical composition of these waters, the chief mineral of one being carbonate of lime, and that of the other, carbonate of soda. The water from the third stratum carries more than one per cent. of mineral matter; whereas, the water from the second stratum carries only a little more than one-tenth as much.

The following notes on the Albany well, known as the Coffey well, were furnished this Survey by Mr. M. O. Leighton, Chief of the Division of Hydro-Economics, U. S. Geological Survey:—

“This well, which was originally a private well, now belongs to the city. It is six inches in diameter, 840 feet deep, and flows about 40 gallons per minute. The water is supposed to possess medicinal properties.

It is used at present as a table water, and to supply a public bath-house and a fountain.

Field analysis by Mr. W. W. Burnham, of the U. S. Geological Survey:—

<i>Constituents Determined</i>	<i>Parts per Million</i>
Chlorine	4.0
Total Carbonates, as Calcium Carbonate.....	127.0
Scale-forming Carbonates, as Calcium Carbonate.....	0.0
Alkali Carbonates, as Sodium Carbonate.....	135.0
Total Hardness, as Calcium Carbonate.....	<hr/> 5.0
Sulphur Trioxide (estimated).....	0.3
Iron	3.0
Odor, Hydrogen Sulphide	0.0
Color	0.0
Turbidity	0.0
Temperature (estimated).....	72° F.

The Coffey well was originally only 580 feet deep; but, since its purchase by the city, it has been extended to 840 feet, in order to increase the flow, which had materially decreased subsequent to the completion of the 12-inch well at the city water-works.”

DUCKER’S STATION. — Col. John P. Fort’s well, near Ducker’s Station, in the western part of Dougherty county, has the distinction of being the first successful flowing well constructed in Georgia. This well, which is two inches in diameter and 547 feet deep,

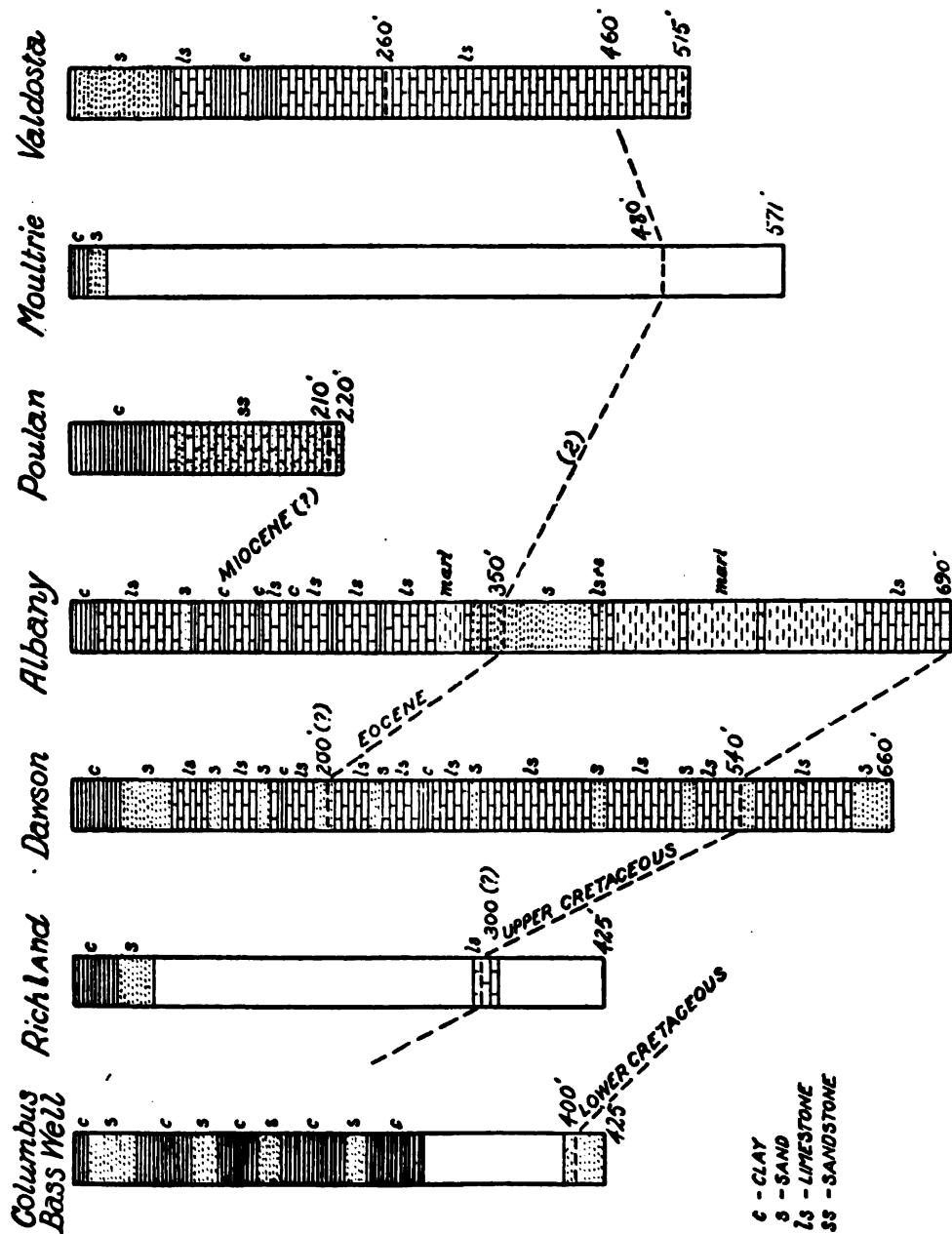


FIG. 3.—Sections of Deep Wells from Columbus, Muscogee County, to Valdosta, Lowndes County, Showing the Depths and the Geological Horizons of the Main Water-bearing Strata.

was completed in 1881, after six months of continuous labor with a rather crude boring-outfit. The water rises ten feet above the surface.

Dr. J. W. Spencer, formerly State Geologist of Georgia, gives the following record of the Fort well:—¹

- | | | | |
|----|--|-----|------|
| "1 | A few feet of surface clay followed by limestone boulders to | 65 | feet |
| 2 | Limestone with silicified layers containing shells and traversed by subterranean streams to..... | 150 | " |
| 3 | Blue marl (clay?) to..... | 165 | " |
| 4 | Shell rock, sand, rock and marl (clay). Water rose to within 14 feet of surface, to..... | 260 | " |
| 5 | Sand, tinted blue; a layer of very fine white sand, at 370 feet, below which some coarse sand with shell fragments and sharks' teeth to..... | 380 | " |
| 6 | Blue clay and sand rock in alternate layers to..... | 410 | " |
| 7 | Blue clay with soft sand rock to flowing water.... | 490 | " |
| 8 | Sand and clay, forming water-bearing stratum to hard rock at | 530 | " " |

HARDAWAY STATION. — Mr. F. F. Putney's well is said to have a depth of 315 feet. It is six inches in diameter, and the water rises to within 50 feet of the surface. Mr. J. D. Stephens, of Albany, has kindly furnished the following meagre record of the well:—

- | | | | |
|---|--|----|------|
| 1 | Yellow clay | 50 | feet |
| 2 | Sand | 50 | " |
| 3 | Hard rock, alternating with sand and clay to bottom of well. | | |

WALKER STATION.—The well of Mr. H. J. Lamar, one mile north of Walker Station, is four inches in diameter and 146 feet deep. The water rises to within 35 feet of the surface. It is hard and sulphureted, and is said to be quite wholesome. No record of the well was obtained.

PRETORIA. — The Red Cypress Lumber Company put down this well in 1902. It is four and a half inches in diameter and 585 feet deep. The well flows, but the height to which the water rises

¹ Geological Survey of Georgia, First Report of Progress, 1891, p. 77.

above the surface is not given. Water-bearing strata are reported at 375 feet and near the bottom of the well; but only the latter furnishes a flow.

The following sanitary analysis of this water has been furnished by the Red Cypress Lumber Company:—

	Parts per Million
Total Solids	178.500
Chlorine	5.950
Free Ammonia .....	.100
Albuminoid Ammonia	—
Nitrates	trace
Nitrites .....	.001

BLUE SPRING. — Dougherty county has several large springs, the most noted of which is the so-called Blue Spring located a few hundred yards from the left bank of the Flint River, about four miles south of Albany. This spring, which furnishes about 70 million gallons per day, is probably the largest spring in the State. It flows from a large cavernous opening in a somewhat circular depression, a few rods west of the highway leading from Albany to Hardaway. The water rises, with considerable force, from the subterranean opening, and forms a stream, several yards wide and from two to eight feet deep. The water is usually quite clear; but, after a heavy rain, it sometimes becomes somewhat cloudy, due evidently to the surface waters finding their way, by means of lime-sinks or otherwise, to the underground stream which supplies the spring.

During the high floods of the Flint River, Blue Spring is submerged by back water; but, so enormous is the flow of the spring, that it is impossible for the muddy waters of the river to reach near the spring. Its water is, therefore, always clear, regardless of the condition of the river.

There are other springs in Dougherty county which furnish considerable volumes of water; but none of them compare in size with Blue spring.



ARTESIAN WELL AT MIDVILLE, BURKE COUNTY, GEORGIA, USED TO OPERATE A SMALL ELECTRIC PLANT.



EARLY COUNTY

There are numerous springs reported in Early county; but the main source of domestic water-supply is the shallow wells. These wells, which vary from 20 to 60 feet in depth, obtain their water-supply chiefly from the Lafayette. In the absence or the thinning of this superficial deposit, the wells penetrate the Eocene beds. The water-supply from the latter beds, especially when they consist of what is known as "rotten limestone," is not so satisfactory for domestic purposes, as the water from the former. This is due to the hardness of the water from the Eocene beds. The water from the Lafayette deposit is always soft; and, when not contaminated by surface impurities, it is a most desirable water for manufacturing and domestic purposes. The deep wells of Early county, which are located at Blakely, Damascus and Kara are here described:—

BLAKELY. —The Blakely deep well, completed in June, 1902, at a cost of about \$3,000.00, has a depth of 812 feet and varies from six to ten inches in diameter. Three different water-bearing strata are reported in this well, at 250, 570 and 812 feet, respectively. The third stratum, which now supplies the city with water, furnishes 290 gallons per minute, without perceptibly lowering the static head of water in the well. The water from the third stratum rises to within 19 feet of the surface. The static head of the other water-bearing strata was not reported.

The following record of the Blakely well has been furnished by Mr. S. S. Chandler, the well contractor, supplemented by a few geological notes by Dr. T. Wayland Vaughan:—

Red, sandy clay	from	1	to	10	ft.
Coarse, grayish sand	"	10	"	20	"
Coarse, light-yellowish sand	"	20	"	30	"
Yellowish, cherty limestone (Vicksburg)	"	30	"	40	"
Yellowish, or grayish, sandstone	"	40	"	50	"
Light-colored, almost white, calcareous sandstone, probably base of Vicksburg-Jackson	"	50	"	70	"
Gray sands, darker at bottom	"	70	"	140	"
Greenish sands, with <i>ostrea divaricata</i>	"	140	"	160	"
Fine, gray sand, hard ledge at bottom	"	160	"	285	"

Fine sand, with some clay.....	from 285 to 290 ft.
Bluish clay	" 290 " 490 "
Quartz sand, with glauconite.....	" 490 " 500 "
Hard sandstone with glauconite. Two oysters, apparently <i>gryphaa</i> and <i>exogyra costata</i>	" 500 " 510 "
Grayish or bluish sands.....	" 510 " 580 "

From 580 feet to the bottom of the well, limestone interstratified with clays and sands is reported. The third water-bearing stratum, which is probably upper Cretaceous, is said to consist of a coarse sand.

The analysis of the water from the third water-bearing stratum, made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia, is as follows:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	8.02	.468
Sulphur Trioxide	9.18	.535
Carbon Dioxide	137.40	8.014
Phosphorus Pentoxide	trace	trace
Chlorine	13.60	.793
Iron Sesqui-oxide and Alumina	0.66	.039
Lime	7.50	.437
Magnesia	3.33	.193
Potash	10.96	.639
Soda	57.10	3.330
<i>Probable Combinations</i>		
Potassium Chloride	17.37	1.013
Sodium Chloride	8.76	.511
Sodium Sulphate	19.97	1.165
Sodium Phosphate	trace	trace
Sodium Carbonate	74.78	4.361
Calcium Carbonate	13.39	.781
Magnesium Carbonate	6.99	.408
Total Solids	139.94	8.161
Free Carbon Dioxide	96.81	5.646

By a comparison of this water with the analyses of the water from the Fort Gaines, the Newton and the lower stratum in the Albany

wells, it will be noticed that there is a marked similarity. They all carry a high percentage of sodium carbonate, and are quite soft.

DAMASCUS. — Mr. C. C. Green's well at Damascus is two inches in diameter and 547 feet deep. Considerable hard rock is reported in this well; but the exact thickness and character of the various formations were not ascertained. Two water-bearing strata were struck in the well, one at 200, and the other at 547 feet. Water from the former rises to within 20 feet of the surface, and from the latter, to within seven feet of the surface. Both strata are said to furnish a good supply of water.

KARA. — The well of Mr. W. R. Carter, located near Cowart's station on the Central of Georgia Railway, between Blakely and Arlington, which was completed in 1897, has a depth of only 120 feet. It varies in diameter from five to six inches, and penetrates only one water-bearing stratum, which was struck at 113 feet from the surface. The drill is said to have dropped 7 feet at that point, into a cavity from which the water rose immediately to within 27 feet of the surface.

Mr. Carter has furnished the following record of the well: —

Reddish clay	from 0 to 30 ft.
Sand	" 30 " 32 "
Limestone; 7-foot cavity at 113 feet.....	" 32 " 120 "

The water-supply of the Damascus and the Kara wells is supposed to come from Eocene beds.

EFFINGHAM COUNTY

Mr. J. C. Overstreet, in answer to enquiry about springs in Effingham county, says: "There are very few springs in the county, and the only ones of any importance are in the Savannah River swamps, all of which are subject to overflows during freshets." The domestic water-supply is obtained almost entirely from shallow wells, which rarely ever attain a depth of more than 40 feet. The water is pure and wholesome, where the wells are properly protected from surface contamination. Successful deep wells have been sunk at Eden, Egypt, Guyton, Meldrim and Pineora.

EDEN. — (*Elevation, 34 feet above sea-level.*) There are two wells located at this place, one 280 feet, and the other 311 feet in

depth. Each well has a diameter of six inches, and furnishes a flow of several gallons of sulphureted water per minute, which rises 12 feet above the surface. Only one flow is reported in the well, and this was struck at about 275 feet. The strata penetrated are said to have been clays and marls, with thin layers of hard rock.

EGYPT. — (*Elevation, 143 feet above sea-level.*) This well was sunk by the Central of Georgia Railway. It is reported to be 750 feet deep and four inches in diameter. Water rises to within 45 feet of the surface. Water-bearing strata were penetrated at 300 and 750 feet from the surface. The strata passed through are said to have been clay, sand and marls, followed by limestone.

GUYTON. — Mr. J. T. Wells' well, which is located about a mile east of Guyton post-office, was completed in 1895 at a cost of \$400.00. The well is three inches in diameter and 400 feet deep; and it furnishes hard, sulphureted water, rising to within 18 feet of the surface. The principal water-bearing stratum, which consists of sand, was struck at 300 feet. An incomplete record is as follows:—

Clay	from	0	to	200	ft.
Rock	"	200	"	201½	"
Rocks in beds (sharks' teeth and shells)...	"	201½	"	396	"
Quicksand	"	396	"	400	"

Field analysis by Mr. W. W. Burnham, of the U. S. Geological Survey:—

<i>Constituents Determined</i>	<i>Parts per Million</i>
Chlorine	6.5
Total Carbonates, as Calcium Carbonate.....	98.8
Scale-forming Carbonates, as Calcium Carbonate....	9.2
Alkali Carbonates, as Sodium Carbonate	95.0
Total Hardness, as Calcium Carbonate.....	96.5
Sulphur Trioxide	trace
Iron	1.0
Odor, Hydrogen Sulphide	3.0
Color	0.0
Turbidity	0.0
Temperature	— The water is cold when pumped.

The above notes were also furnished by Mr. W. W. Burnham.

MELDRIM. — (*Elevation, 30 feet above sea-level.*) There are two deep wells at Meldrim, one of which was sunk by the Central of Georgia Railway. It is reported to attain a depth of 538 feet. It is

six inches in diameter and furnishes a good flow, rising four feet above the surface. The daily capacity of this well is said to be about 40,000 gallons. The water is used to supply the locomotives of the Central Railway; and for general domestic purposes.

Field analysis by Mr. W. W. Burnham, of the U. S. Geological Survey:—

<i>Constituents Determined</i>	<i>Parts per Million</i>
Chlorine	6.5
Total Carbonates, as Calcium Carbonate.....	108.0
Scale-forming Carbonates, as Calcium Carbonate...	13.0
Alkali Carbonates, as Sodium Carbonate.....	101.0
Total Hardness as Calcium Carbonate.....	124.0
Sulphur Trioxide (estimated)	5.0
Iron	trace
Odor, Hydrogen Sulphide	4.0
Turbidity	0.0
Color	0.0
Temperature (estimated)	70° F.

The other Meldrim well, owned by Mr. C. B. Guyer, is located about 300 yards west of the post-office. It is six inches in diameter and 350 feet deep; and it flows about 50 gallons of sulphureted water per minute.

The water is said to rise 50 feet above the surface. It is used at present only for general domestic purposes; but Mr. Burnham, who furnished these data, notes that it is Mr. Guyer's intention to use the water soon for irrigation.

Field analysis by Mr. W. W. Burnham, of the U. S. Geological Survey:—

<i>Constituents Determined</i>	<i>Parts per Million</i>
Chlorine	6.5
Total Carbonates, as Calcium Carbonate.....	114.0
Scale-forming Carbonates, as Calcium Carbonate...	20.0
Alkali Carbonates, as Sodium Carbonate.....	100.0
Total Hardness, as Calcium Carbonate.....	124.0
Sulphur Trioxide (estimated)	5.0
Iron	trace
Odor, Hydrogen Sulphide	4.0
Color	0.0
Turbidity	0.0
Temperature (estimated)	76° F.

PINEORA. — No data on the Pineora well were secured.

EMANUEL COUNTY

Successful deep wells have been sunk in Emanuel county at Swainsboro, Adrian and Stillmore.

SWAINSBORO.—Messrs. Jesse Thompson & Company's deep well at Swainsboro is 400 feet deep and six inches in diameter. The water rises to within 80 feet of the surface. The water-bearing stratum, which supplies this well, was struck at a depth of 370 feet from the surface. A trial test with a pump, having a capacity of 30,000 gallons per day, is said to have had no effect upon the static head. The borings from the well are reported to have shown, that the different strata penetrated consisted of sand, clay, blue marl and hard and soft rock, the last named being most abundant.

A second deep well at Swainsboro, owned by Mr. R. J. Williams, has the same depth as the first well; but it is only two inches in diameter. The water in this well is said to rise to within 90 feet of the surface. Three different water-bearing strata are reported to have been struck; but their depth from the surface is not given. No information was obtained concerning the formation penetrated. The static head of the water in this well is said to vary slightly, from time to time. The amount of water furnished per hour is about 600 gallons.

In addition to the two deep wells here described, there is a third well in Swainsboro, which was put down by the town authorities. No information, however, has been received concerning the well, except that it is 889 feet deep, and supplies the town with water.

ADRIAN.—A deep well at Adrian, owned by the town, has a depth of 300 feet. It furnishes a good supply of wholesome water, which rises to within 60 feet of the surface. There are, also, two other deep wells reported in Adrian, and one on the Ochoopee River, about one mile west of Adrian; but no record of these wells has been received.

STILLMORE.—Mr. G. M. Brinson's well, located within the corporate limits of Stillmore, has a depth of 679 feet, and is six inches in diameter. It furnishes an abundance of water, which rises to within 70 feet of the surface. The water, which has been used

largely for steam purposes, is said to be hard and forms scale in boilers. This difficulty has been partly obviated, however, by mixing the water with that of shallow wells, before introducing it into the boilers.

With the exception of the towns above named, the domestic water-supply of Emanuel county is obtained almost entirely from shallow wells. Springs, no doubt, occur in the county; but their locations have not been reported. The water-bearing strata, supplying the deep wells, appear to be Eocene.

GLYNN COUNTY

With the exception of the city of Brunswick, the main source of the domestic water-supply of Glynn county is the shallow wells. These wells, which rarely ever attain a depth of more than 20 or 30 feet, obtain their water-supply from the Pleistocene or Pliocene sands and clays. The water obtained from this source is usually soft and especially well adapted to manufacturing purposes. The springs of Glynn county are few in number and small in size. There occur, at a few points in the county, small springs, whose waters are impregnated with hydrogen sulphide. These have a local interest, on account of their supposed medicinal properties. A spring of this description is to be seen near the shell-road, a short distance west of Brunswick. The spring is small, furnishing only a few gallons of sulphureted water per hour, and is apparently of little consequence.

Glynn county has a large number of artesian wells, more than a score of which are located within, or near, the city-limits of Brunswick. These are all flowing wells. They furnish a large supply of wholesome water.

Brunswick. — The City of Brunswick is at present supplied by three deep wells, located at the pumping-station near the Southern Railway depot. There are also a number of private wells in the city. Nearly all the large manufacturing plants, as well as a number of individuals, own one or more deep wells. Since the completion of so many wells in the city, it is said, that the amount of flow has been perceptibly decreased. The wells at the water-works, which originally furnished ample water by natural flow, have now to be

pumped, in order to furnish the necessary supply. The cause of this decrease in flow is no doubt due to an overdraft on the water-bearing strata.

These wells usually vary from about 300 to 400 feet in depth. There are, however, two or three wells, which attain a much greater depth. Col. C. P. Goodyear's well, for instance, located in the southern part of the city, is reported to reach a depth of 822 feet. This well penetrated water-bearing strata at 302, 425 and 525 feet, the latter stratum furnishing a flow of 250 gallons per minute. The water from these different horizons rises about 12, 28 and 57 feet, respectively above the surface.

Mr. Fred Baumgardner, the well contractor, who put down many of the Brunswick wells, has furnished the survey the following record of the high school well:—

Yellow sand	from	0	to	55	ft.
Thin layers of sandstone interlaminated with clay.	"	55	"	112	"
Blue clay or marl.....	"	112	"	212	"
Soft, porous limestone with shells.....	"	312	"	332	"
Coarse sand and pebbles.....	"	332	"	357	"
Hard rock	"	357	"	359	"
Blue marl or clay.....	"	359	"	459	"
Thin layers of limestone with clay and sand....	"	459	"	479	"
Very fine, white sand at.....				479	"

The following additional notes are made on samples of well-borings, furnished by Mr. Baumgardner and Mr. L. L. Deering:—

Grayish sandy clay, with fragments of shells and diatoms	from	50	to	120	ft.
The same as above.....	"	120	"	150	"
White sand, with glauconite, marked first water-bearing stratum	"	150	"	307	"
Fossils identified by Dall as "Pleistocene material" at				350	"
Coral identified by Dall as Pliocene at.....				460	"

The analysis here given, made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia, is made from water obtained from the first water-bearing stratum:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	24.20	1.411
Sulphur Trioxide	52.94	3.087
Carbon Dioxide	97.80	5.703
Phosphorus Pentoxide	trace	trace
Chlorine	17.50	1.021
Iron Sesqui-oxide and Alumina.....	5.40	.315
Lime	43.56	2.540
Magnesia	30.70	1.790
Potash	9.20	.537
Soda	30.85	1.799
<i>Probable Combination</i>		
Potassium Chloride	14.57	.850
Sodium Chloride	17.38	1.014
Sodium Sulphate	49.56	2.890
Sodium Phosphate	trace	trace
Magnesium Sulphate	59.16	3.450
Magnesium Carbonate	23.06	1.345
Calcium Carbonate	77.78	4.536
Total Solids	271.11	15.811
Carbon Dioxide	51.50	3.003

The character of the water from the second water-bearing stratum is shown by the following analysis, also made by Dr. Edgar Everhart, in the laboratory of the Geological Survey of Georgia: —

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	15.20	.886
Sulphur Trioxide	70.41	4.110
Carbon Dioxide	87.00	5.070
Phosphorus Pentoxide	1.75	.102
Chlorine	27.20	1.586
Iron Sesqui-oxide and Alumina.....	27.12	1.581
Lime	46.44	2.708
Magnesia	12.44	.721
Potash	2.91	.176
Soda	67.52	3.936

Probable Combination

Potassium Chloride	4.62	.270
Sodium Chloride	41.20	2.403
Sodium Sulphate	102.11	5.955
Sodium Phosphate	2.61	.152
Magnesium Sulphate	19.32	1.130
Magnesium Carbonate	12.60	.735
Calcium Carbonate	82.94	4.837
Total Solids	307.72	17.946
Free Carbon Dioxide	43.90	2.560

The sample of water, from which the last analysis was made, was obtained from Mr. H. W. Loyd's well, located two miles north of Brunswick. The well is 485 feet deep and four inches in diameter. The water rises 27 feet above the surface, and is used chiefly for irrigation purposes.

Mr. Fred Baumgardner's well, located at his residence near Mr. Loyd's, is also used for irrigation.

JEKYL ISLAND. — The well of the Jekyl Island Club, which furnishes 250 gallons per minute, is six inches in diameter and 480 feet deep. The flow of the well is said to have perceptibly decreased since its completion. Whether this decrease is due to an accumulation of sand in the casing, or to an overdraft on the water-bearing stratum, is not known. The superintendent of the Jekyl Island club has furnished the following analysis of this water, made by Prof. H. C. White, of the University of Georgia: —

<i>Constituents Determined</i>	<i>Grains per U. S. Gallon</i>
Carbonate of Lime	8.083
Sulphate of Soda	3.864
Sodium Chloride	1.457
Potassium Chloride	0.085
Sulphate of Lime	1.324
Sulphate of Magnesia	0.615
Silica	0.068
Organic Matter and Combined Water	1.256
Total	16.752

ST. SIMON'S ISLAND. — There are four artesian wells reported on St. Simon's Island, varying in depth from 438 to 465 feet. The only one of these wells, from which anything like a detailed account has been preserved, is the Hilton & Dodge Lumber Company's well at St. Simon's Mills. This well, which was sunk in 1886, is six inches in diameter and 438 feet deep. It furnishes 250 gallons of sulphureted water per minute. The water rises 40 feet above the surface. It is largely used for steam purposes. The first flow in this well was struck at 350 feet. It yielded eight gallons per minute. The second flow began at 435 feet, and gradually increased to the bottom of the well.

The following notes on the different strata penetrated in the well are made from a series of borings furnished by the Hilton & Dodge Lumber Company: —

Very fine, gray sand to.....	10 feet
Dark-colored marsh-mud containing fragments of shells to.	20 "
Rather coarse gray sand, with fragments of oyster and other shells to	40 "
Quite similar to overlying sand, somewhat coarser, with only a few shells to.....	50 "
Coarse gray sand and water-worn pebbles of quartz and feldspar. The pebbles are often an inch or more in diameter to	60 "
Very coarse sand and water-worn pebbles of quartz and feldspar. The pebbles are often an inch or more in diameter to	70 "
Moderately coarse sand and pebbles and comminuted shells to	80 "
Fine dark-gray sand and pebbles to.....	90 "
Fine brown sand and a few angular quartz pebbles, with clay to	100 "
Fine dark-gray sand, similar to that found at 90 feet.....	110 "
A conglomerate of quartz pebbles and coarse sand with clay matrix. There occur in the conglomerate a few dark, or brown-colored, small, rounded particles, consisting largely of calcium phosphate to.....	115 "
Coarse gray sand and fragments of shells. The sand granules are well rounded and consist of feldspar of dark color to	120 "
The same as above, except that the fragments of shells are more abundant to	125 "

Fine gray sand with some mica to.....	133	feet
Fine gray sand and quartz pebbles to.....	143	"
Similar to the above, except darker and with less clay to..	153	"
Fine gray sand with mica to.....	160	"
The same as above to.....	170	"
Fine gray sand to	180	"
Fine, light-gray sand with much mica to.....	190	"
Fine, dark-gray, clayey sand with mica, diatoms and spic- ules of sponges to.....	200	"
The same as above, but darker to.....	230	"
Fine sand with numerous diatoms and spicules of sponges to	250	"
Diatomaceous earth, containing an innumerable number of microscopic rhombohedral crystals of calcite to.....	310	"
Fine, light-gray, micaceous sand with mica and small teeth resembling those of the gar-pike to.....	320	"
Rather coarse, gray sand containing sharks' teeth, dental plates of rays (?), fragments of bones, and small pieces of clay containing diatom shells and sponge spicules to..	324	"
Gray sandstone, or quartzite, containing casts of shells and glauconite to	327	"
Moderately coarse gray sand to.....	330	"
Coarse, water-worn sand, with small sharks' teeth to.....	350	"
The same as above, except that it contains fragments of shells, to	360	"
Dark-gray marl, made up largely of microscopic crystals of calcite, to.....	370	"
Dark-gray marl, as above, to.....	380	"
The same as above to.....	390	"
The same as above to.....	400	"
Very compact, fine, dark-gray clay, slightly tinged with green, to	410	"
Fine, dark-gray clay, frequently indurated. Glauconite, more or less abundant, to.....	420	"
Coarse, dark-colored, glauconitic sand, containing small teeth of sharks, to.....	430	"
Coarse, dark sand, with rounded pebbles of quartz and feldspar to	435	"
Fine, white sand to	438	"

The following field analysis of the water from the Hilton & Dodge Lumber Company's well has been furnished by Mr. M. O. Leighton, Chief of the Division of Hydro-Economics, United States Geological Survey:—

Field analysis by Mr. W. W. Burnham, of the U. S. Geological Survey:—

<i>Constituents Determined</i>	<i>Parts per Million</i>
Chlorine	19.0
Total Carbonates, as Calcium Carbonate.....	121.0
Scale-forming Carbonates, as Calcium Carbonate.....	22.7
Alkali Carbonates, as Sodium Carbonate.....	103.0
Total Hardness as Calcium Carbonate.....	221.0
Sulphur Trioxide	69.0
Odor, Hydrogen Sulphide	3.0
Iron	0.8
Color	0.0
Turbidity	0.0

BLADEN. — (*Elevation, 15 (?) feet above sea-level.*) The Bladen deep well, owned by Mr. J. A. Ward, has a depth of 480 feet. It is three inches in diameter, and flows about 100 gallons per minute. The water, which is used for domestic and steam purposes, rises 30 feet above the surface. It is hard and sulphureted. Water-bearing strata are reported at 160, 260 and 475 feet, respectively. Nothing is known of the strata penetrated in the well, except that they consist of clay and sand, with a few beds of rock and oyster shells.

EVERETT CITY.—(*Elevation, 16 feet above sea-level.*) Mr. R. H. Everett's well, at Everett City, was put down in 1894. It is 460 feet deep and two inches in diameter, and it furnishes a flow 38 feet above the surface. The water is hard and sulphureted, and is used for domestic and steam purposes. No record of the well was secured.

The following field analysis has been furnished by Mr. M. O. Leighton, Chief of the Division of Hydro-Economics, U. S. Geological Survey:—

Field analysis by Mr. W. W. Burnham, of the U. S. Geological Survey:—

<i>Constituents Determined</i>	<i>Parts per Million</i>
Chlorine	21.5
Total Carbonates, as Calcium Carbonate.....	111.0
Scale-forming Carbonates, as Calcium Carbonates.....	11.0
Alkali Carbonates, as Sodium Carbonate.....	106.0
Total Hardness, as Calcium Carbonate.....	207.0

	Parts per Million
Sulphur Trioxide	90.0
Iron	trace
Odor, Hydrogen Sulphide	3.0
Color	0.0
Turbidity	0.0
Temperature (estimated)	74° F.

CRISPIN. — A flowing well, owned by Mr. Harry Gignilliat, and located six miles northwest of Brunswick, on the road leading to Crispin, has a depth of 377 feet. It is four inches in diameter, and it furnishes 50 gallons of sulphureted water per minute. Water-bearing strata are reported at 200 and 270 feet, respectively. Water from the first stratum is said to rise to within eight feet of the surface; and, from the last, 14½ feet above the surface.

Mr. L. L. Deering, the well-contractor, gives the following record of the Gignilliat well: —

	from	0 to	4 feet
Sand	"	4	" 12 "
Clay	"	12	" 14 "
Sand	"	14	" 26 "
Clay	"	26	" 36 "
Sand	"	36	" 46 "
Clay	"	46	" 66 "
Sand and shells	"	66	" 68 "
Rock	"	68	" 88 "
Clay	"	88	" 100 "
Sand rock	"	100	" 130 "
Clay	"	130	" 133 "
Rock	"	133	" 163 "
Clay	"	163	" 168 "
Sand	"	168	" 188 "
Clay	"	188	" 191 "
Rock	"	191	" 220 "
Sand and shells (water-bearing)	"	220	" 230 "
Clay	"	230	" 272 "
Sand	"	272	" 280 "
Clay	"	280	" 288 "
Sand	"	288	" 304 "
Clay	"	304	" 310 "
Rock	"	310	" 325 "
Clay	"	325	" 327 "
Rock	"		

Clay	from 327 to 357 feet
Rock	" 357 " 362 "
Clay	" 362 " 370 "
Rock (water-bearing)	" 370 " 377 "

EVELYN.—(*Elevation, 20 feet above sea-level.*) Mr. J. T. Dent's well at Evelyn, in the northern part of Glynn county, has a depth of 420 feet. It is two inches in diameter, and the water rises 14 feet above the surface. The first flow was struck at 370 feet from the surface; but the well was continued to 420 feet without increase of flow. The water is sulphureted, and is used for farm and general domestic purposes.

CHAPTER VIII

DETAILED DESCRIPTION OF THE UNDERGROUND WATERS OF THE COASTAL PLAIN, BY COUNTIES (*Continued*)

HOUSTON COUNTY

The chief supply of domestic water in Houston county is obtained from shallow wells. These wells, which are usually from 30 to 60 feet in depth, obtain their water-supply chiefly from the Lafayette sands and clays. There are numerous springs in the county; but they are usually small. Deep wells are located at Fort Valley, Perry and Byron.

FORT VALLEY.—(*Elevation, 531 feet above sea-level.*) The Fort Valley well, which is owned by Mr. H. C. Harris, is four inches in diameter and 1,075 (?) feet deep. Its water rises to within 100 feet of the surface. The well is now abandoned.

Mr. Harris has furnished the Survey the following record:—

1	Red clay	20 feet
2	Sand	20 "
3	White clay	8 "
4	Yellow sand	40 "
5	White clay	10 "
6	Quicksand with pebbles.....	400 "
7	Hard rock	Thickness not given
8	Quicksand	" " "

At a depth of 300 feet from the surface, a water-bearing stratum is reported to have been struck, which forced the water for a few minutes 20 feet above the surface; but the pressure was soon relieved, and the water subsided to 100 feet below the surface. Other



WATER-WORKS PLANT AT ALBANY, GEORGIA.



water-bearing strata were struck in the well below 300 feet; but the static head remained unchanged. A second well was attempted by Mr. Harris, by what is known as the dry method of well-boring; but the process was found unsuccessful in the quicksands, and the well was finally abandoned.

PERRY. — The well at this place, which was put down by the town authorities, is four inches in diameter and 138 feet deep. The water rises to within about 42 feet of the surface. The only water-bearing stratum reported in the well occurs at 136 feet. The well, which is supplied with a hand pump, is used only to a limited extent, owing to the water tasting strongly of iron.

The following record of the well has been given: —

Red massive clay.....	from	0	to	10	feet
White clay	"	10	"	10 $\frac{1}{3}$	"
Yellowish sand, with 4 inches of imper- vious iron ore at its base.....	"	10 $\frac{1}{3}$	"	50	"
Sand with thin partings of clay.....	"	50	"	132	"
Dark carbonaceous material — possibly lignite	"	132	"	136	"
Coarse gravel at.....				136	"

The following analysis of the water from the Perry well was made by Mr. W. H. Hollinshead, of Vanderbilt University: —

<i>Constituents Determined</i>	<i>Grains per U. S. Gallon</i>
Alumina	0.460
Iron Sesqui-oxide	0.302
Zinc	0.551
Calcium	0.256
Magnesium	0.078
Sodium	0.354
Potassium	trace
Lithium	trace
Chlorine	0.126
Sulphuric Acid	0.453
Silicic Acid	0.648
Phosphoric Acid	0.092
Total	3.320

The zinc shown in the analysis is supposed to have been derived from the galvanized pipe of the pump.

BYRON. — (*Elevation, 515 feet above sea-level.*) The following notes on Mr. J. H. Peavey's well, located at Byron, are furnished by Mr. W. W. Burnham, of the U. S. Geological Survey: — "The well was completed in June, 1902, at a cost of \$335. It is three inches in diameter and 310 feet deep; and it penetrates water-bearing strata at 210, 275 and 310 feet. Water rises to within 185 feet of the surface, the maximum supply being 50 gallons per minute. The well is now abandoned. The well record is as follows: —

Sand and "Chalk" (Kaolin).....	from	0	to	250	feet
Quicksand and "Chalk" (Kaolin) in 3-foot					
layers. Water-bearing stratum, coarse Sand	"	250	"	310	"

The water-supply of the deep wells of Houston county is obtained from the Cretaceous.

IRWIN COUNTY

There are numerous small springs in Irwin county, but the main source of domestic water-supply is the shallow wells. Successful deep wells have been sunk at Fitzgerald and Ocilla.

FITZGERALD. — (*Elevation, 430 feet above sea-level.*) There are three deep wells within the corporate limits of Fitzgerald, one of which supplies the town with water. This well is eight inches in diameter and 825 feet deep; and it has a capacity of 5,000 gallons of water per hour, without perceptibly lowering the static head. The water rises to within 150 (?) feet of the surface. It is said to come from a porous limestone, at a depth of from 370 to 500 feet from the surface.

The record of the Fitzgerald Ice Company's well, which attains a depth of only 381 feet, is as follows: —

Red Clay and Sand.....	from	0	to	100	feet
Quicksand (?)	"	100	"	225	"
Limestone with some Clay	"	225	"	381	"

The data obtained from the Fitzgerald wells are very meagre, and are not considered reliable.

An analysis of the water from the city well, made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia, is as follows:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	13.07	.762
Sulphur Trioxide	3.06	.180
Carbon Dioxide	76.20	4.444
Phosphorus Pentoxide	trace	trace
Chlorine	20.40	1.190
Iron Sesqui-oxide and Alumina.....	10.19	.594
Lime	27.78	1.620
Magnesia	8.62	.503
Potash	2.26	.073
Soda	11.15	.650
<i>Probable Combinations</i>		
Potassium Chloride	3.58	.208
Sodium Chloride	21.04	1.227
Sodium Phosphate	trace	trace
Magnesium Chloride	7.92	.462
Magnesium Sulphate	4.59	.268
Magnesium Carbonate	7.89	4.60
Calcium Carbonate	49.61	2.893
Total Solids	117.89	6.292
Free Carbon Dioxide	50.24	2.930

The water-bearing strata supplying the Fitzgerald deep wells are probably Eocene.

OCILLA. — There are five deep wells at Ocilla; but from only one, namely, the Ensign Oskamp Company's well has the writer been able to secure data. The information here given concerning the well was secured by Mr. W. W. Burnham from the chief engineer of the Ensign Oskamp Company. This well, which was put down in 1900 at a cost of \$1,200, is six inches in diameter and 512 feet deep. The water rises to within 40 feet of the surface; but, by continuous pumping, it is lowered to 120 feet. The maximum

yield is 35 gallons per minute. The water is used with surface water, after being treated with boiler compound, for steam purposes. Water-bearing strata are reported at 312 and 496 feet, respectively. The following record of the well is from memory:—

Soil and clay	from	0	to	60	feet
Soft rock	"	60	"	76	"
Sand	"	76	"	105	"
Rock	"	105	"	300	"
Very hard rock	"	300	"	312	"
Porous limestone with cavities 4 feet deep...	"	312	"	512	"

Field analysis by Mr. W. W. Burnham, of the U. S. Geological Survey:—

<i>Constituents Determined</i>	<i>Parts per Million</i>
Chlorine	4.0
Total Carbonates, as Calcium Carbonate.....	108.0
Scale-forming Carbonates, as Calcium Carbonate.....	22.0
Alkali Carbonates, as Sodium Carbonate.....	91.0
Total Hardness, as Calcium Carbonate.....	—
Sulphur Trioxide	0.0
Iron	1.0
Odor, Hydrogen Sulphide	2.0
Color	0.0
Turbidity	0.0
Temperature (estimated).....	60° F.

JEFFERSON COUNTY

Jefferson county has a large number of deep wells; but the main source of water for domestic purposes is shallow wells, which obtain their water-supply from the Lafayette, or the underlying sands and clays. The water of these wells is usually soft, and is regarded by the inhabitants as being very wholesome. The maximum depth of these wells rarely ever exceeds 50 feet. They are often more or less affected by droughts; but, as a general rule, they furnish an ample supply of water for farm and domestic purposes, even during the driest seasons.

There are several large springs in Jefferson county; but the only one visited by the writer was the large spring known as Blue Spring.

located near the Burke county line, about nine miles east of Louisville. This spring, which furnishes sufficient water to operate a grist-mill, boils up through white sand in the bottom of a circular basin, several feet in diameter. The water is clear, and is said to be quite wholesome.

The deep wells of Jefferson county, which are located at Louisville, Wadley, Bartow, Old Town and Wren are described as follows:—

LOUISVILLE. — There are five artesian wells in or near Louisville, varying in depth from 350 to 450 feet. Water-bearing strata were struck in these wells at 200 and 300 feet, the main water-supply being obtained from the latter stratum. Only those wells which are located on low ground furnish a flow.

The following notes, on the strata penetrated in putting down the Louisville deep wells, were obtained from Mr. G. H. Harrell, of Louisville:—

1	Red, motley clays.....	25.0	feet
2	Fine yellow sand.....	40.0	"
3	Quicksand	6.0	"
4	Marl, with fragments of shell.....	8.0	"
5	Blue marl	100.0	"
6	Flint	0.5	"
7	Marl, honey-combed rock and lignite.....	100.0	"
8	Coarse sand with mica.....	(?)	

In addition to the wells above noted, there is also another well located at a water-station, two miles south of Louisville, on the Louisville and Wadley Railroad. This is a four-inch well, 325 feet deep; and it furnishes 20 gallons of water per minute. Two water-bearing strata were struck in this well, one at 150, and the other at 300 feet from the surface. The former furnishes only a small flow; while the water from the latter rises 20 feet above the surface.

The following analysis by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia, was made from the water obtained from the flowing well, which is located at the Fair Grounds near the corporate limits of Louisville:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	39.22	2.287
Sulphur Trioxide	7.75	.450
Carbon Dioxide	53.90	3.140
Phosphorus Pentoxide	2.50	.146
Chlorine	8.16	.476
Iron Sesqui-oxide and Alumina.....	4.12	.240
Lime	46.44	2.708
Magnesia	2.31	.128
Potash	3.36	.196
Soda	4.18	.244
<i>Probable Combination</i>		
Potassium Chloride	5.53	.322
Sodium Chloride	7.88	.460
Sodium Phosphate	3.59	.209
Magnesium Chloride	1.11	.059
Magnesium Sulphate	5.55	.322
Calcium Sulphate	6.89	.401
Calcium Carbonate	77.84	4.540
Total Solids	151.73	8.790
Free Carbon Dioxide.....	19.66	1.146

OLD TOWN. — There are two artesian wells at Old Town, both having about the same flow, and furnishing water of similar character. Water-bearing strata are reported at 160 and 200 feet. Clays, sands, marls and limestones are said to have been passed through, in sinking the well; but their thickness and depth from the surface are not given. The wells are about 225 feet deep, and flow 28 feet above the surface.

WADLEY.—(*Elevation, 243 feet above sea-level.*) There are several flowing wells at Wadley, varying from 330 to 450 feet in depth. Three different water-bearing strata are reported in all the deepest wells, the first occurring at 170, the second at 330, and the third at 430 feet. The water from these different strata rises from four to twenty feet above the surface. An attempt was made some years ago, to run a mill by water from two or three of these wells; but

the experiment proved unsuccessful. The water is used only for general domestic purposes.

Mr. M. M. Caldwell has furnished the following record of one of the Wadley deep wells:—

1	Yellow Clay	60 feet
2	Blue Marl	100 "
3	Sand	2 "
4	Marl and Limestone.....	250 "
5	Sand	Not given

An analysis of the water, made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia, is as follows:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	13.00	.758
Sulphur Trioxide	9.14	.533
Carbon Dioxide	150.60	8.783
Phosphorus Pentoxide	trace	trace
Chlorine	4.70	.274
Iron Sesqui-oxide and Alumina.....	1.80	.105
Lime	80.40	4.689
Magnesia	5.14	.300
Potash	3.55	.207
Soda	12.40	.723
<i>Probable Combinations</i>		
Potassium Chloride	5.62	.328
Sodium Chloride	3.31	.193
Sodium Sulphate	19.88	1.159
Sodium Phosphate	trace	trace
Sodium Carbonate	3.36	.196
Magnesium Carbonate	10.79	.629
Calcium Carbonate	143.57	8.372
Total Solids	191.33	11.158
Free Carbon Dioxide.....	80.38	4.688

BARTOW.—(*Elevation, 237 feet above sea-level.*) There are three deep wells at Bartow, which vary from 160 to 525 feet in depth. The deepest wells are said to penetrate water-bearing strata at 60,

225 and 350 feet, the two last strata furnishing flows which rise from seven to ten feet above the surface.

Mr. L. B. Clay, who sunk the deepest well in Bartow, has furnished the following record from memory:—

Red sandy clays.....	from	0	to	12	feet
Coarse gravel (?).....	"	12	"	52	"
Marl and sand (water-bearing).....	"	52	"	112	"
Blue marl with an occasional layer of rock..	"	112	"	362	"
Same as above, with sharks' teeth and shells.	"	362	"	525	"

WREN. — The following data on the Wren well, received from Mr. W. W. Burnham, was furnished by Mr. M. O. Leighton, Chief of the Division of Hydro-economics, U. S. Geological Survey:—

This well, which belongs to Mr. W. J. Wren, is located within a few hundred feet of the railway station. It is six and four inches in diameter and 556 feet deep, and it furnishes a maximum yield of 80 gallons per minute. The principal water-bearing stratum is at 525 feet from the surface; and the water rises to within 20 feet of the surface. It is used for general domestic and boiler purposes. The well was put down in 1897, at a cost of \$400.

The field analysis of the water, which is said to form scale in boilers, is as follows:—

Field analysis by Mr. W. W. Burnham, of the U. S. Geological Survey:—

<i>Constituents Determined</i>	<i>Parts per Million</i>
Chlorine	1.5
Total Carbonates, as Calcium Carbonate.....	60.6
Scale-forming Carbonates, as Calcium Carbonate.....	3.4
Alkali Carbonates, as Sodium Carbonate.....	60.6
Sulphur Trioxide	trace
Total Hardness, as Calcium Carbonate.....	110.4
Iron	4.0
Color	trace
Odor, Hydrogen Sulphide.....	3.0
Turbidity	0.0

OIL PROSPECTING WELL. — The location of this well is about $3\frac{1}{2}$ miles southwest of Louisville on what is known as the Black farm. Mr. James Tague, the contractor, gives the following record of the well:—

Mixed clay and sand.....	from	0	to	68	feet
Sand and rock.....	"	68	"	74	"
Blue clay	"	74	"	76	"
Blue clay and sand.....	"	76	"	91	"
Blue clay	"	91	"	93	"
Sand	"	93	"	96	"
Hard rock	"	96	"	96	"
Soft sand rock	"	96	"	99	"
Sand	"	99	"	113	"
Hard rock	"	113	"	114	"
Sand	"	114	"	116	"
Soft rock	"	116	"	119	"
Hard rock	"	119	"	120	"
Blue clay	"	120	"	132	"
Sand rock	"	132	"	142	"
Sand and clay	"	142	"	150	"
Blue clay	"	150	"	169	"
Sand	"	169	"	171	"
Blue clay and shale.....	"	171	"	176	"
Hard rock	"	176	"	177	"
Blue clay and sand layers.....	"	177	"	184	"
Hard rock	"	184	"	188	"
Sand	"	188	"	204	"
Hard rock	"	204	"	205	"
Blue and white clay.....	"	205	"	208	"
Hard rock	"	208	"	209	"
Sand	"	209	"	213	"
Shale	"	213	"	219	"
Sand	"	219	"	223	"
Blue clay and shale.....	"	223	"	269	"
Fine sand	"	269	"	275	"
Clay and shale	"	275	"	298	"
Fine sand	"	298	"	307	"
Sand	"	307	"	505	"
Red clay	"	505	"	510	"
Red and white clay.....	"	510	"	532	"
Red clay	"	532	"	562	"
Sand	"	562	"	581	"
White clay	"	581	"	583	"
Hard clay	"	583	"	584	"
Clay	"	584	"	588	"
Sand with gas	"	588	"	599	"
Sand with hard layers.....	"	599	"	661	"

Mixed clay	.....	from	661	to	665	feet
Sand	.....	"	665	"	704	"
Mixed clay	.....	"	704	"	741	"
Sand	.....	"	741	"	751	"
Clay	.....	"	751	"	759	"
Sand	.....	"	759	"	775	"
Tough clay	.....	"	775	"	783	"
Sand	.....	"	783	"	793	"
Hard layer	.....	"	793	"	798	"
Sand	.....	"	798	"	800	"
Sandy clay	.....	"	800	"	843	"
Sand	.....	"	843	"	853	"
Mixed clay	.....	"	853	"	870	"
Sand	.....	"	870	"	896	"
Mixed clays	.....	"	896	"	913	"
Sand	.....	"	913	"	929	"
Clay	.....	"	929	"	948	"
White and yellow sand	.....	"	948	"	955	"
White clay	.....	"	955	"	965	"
Sand	.....	"	965	"	976	"
Shale	.....	"	976	"	979	"
Clay	.....	"	979	"	999	"
Sand	.....	"	999	"	1001	"
Clay	.....	"	1001	"	1006	"
Hard layer	.....	"	1006	"	1006	"
Blue clay	.....	"	1006	"	1027	"
Sand	.....	"	1027	"	1035	"
Clay	.....	"	1035	"	1052	"
Sand	.....	"	1052	"	1058	"
Shale	.....	"	1058	"	1062	"
Sand	.....	"	1062	"	1068	"
Clay	.....	"	1068	"	1088	"
Clay and shale	.....	"	1088	"	1111	"
Very hard shale	.....	"	1111	"	1133	"
Cemented gravel	.....	"	1133	"	1140	"
Hard rock	.....	"	1140	"	1143	"

In addition to the well record above given, Mr. Tague also furnished thirty samples of well borings which seem to verify fairly well his well record. The only samples in the collection of borings, which contained organic remains, that throw any light whatever on the geological formations penetrated, are from depths 250, 380 and

1,143 feet from the surface. Sample from 250 feet contains numerous fragments of oysters and other shells, together with a small coral, which is one of the common fossils of the Claiborne or Lower Tertiary formation. Sample from 380 feet is a fragment of a turtle shell, found, as far as I know, only in the Upper Cretaceous formation. Sample from 1,143 feet contains fragments of a diorite-schist, one of the typical crystalline rocks met with throughout the Piedmont area of Central Georgia.

JOHNSON COUNTY

As far as was reported, there are no springs of any importance in Johnson county. The domestic water-supply is obtained chiefly from shallow wells. The only deep well reported in the county is at Wrightsville, the county seat. This well is four inches in diameter and 578 feet deep. The water rises to within 62 feet of the surface. Water-bearing strata are reported at 430 feet, and also near the bottom of the well. The well at present furnishes about 30 gallons of water per minute, the capacity of the pump, which supplies the town. The water is said to be quite wholesome, and to possess medicinal properties.

An analysis of the water, made by Prof. H. C. White, of the University of Georgia, is as follows:—

<i>Solid Matter Dissolved</i>	Grains per U. S. Gallon
Carbonate of Lime	8.935
Carbonate of Iron .....	.276
Sulphate of Lime .....	.210
Sulphate of Magnesia .....	.623
Sulphate of Soda .....	.324
Sodium Chloride .....	.543
Silica .....	.753
Organic Matter and Water Combined.....	2.415

There is dissolved in the water considerable carbon dioxide, and also some hydrogen sulphide.

The stratum, from which the water is obtained in the Wrightsville well, seems to be Eocene.

LAURENS COUNTY

The only successful deep wells, reported in Laurens county, are at Dublin, the county seat. These wells, which are all flowing, are said to vary from about 300 to 850 feet in depth. Water-bearing strata are reported at 185 and 295 feet, the latter yielding a flow which rises about 30 feet above the surface. The various formations, passed through in these wells, are reported by Mr. Deering, one of the well contractors, to be very similar to those penetrated in the Hawkinsville wells, except that the limestone occurs near the surface. The water-bearing strata of the Dublin wells are Eocene.

An analysis of the water from one of the city wells, made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia, is as follows:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	20.32	1.185
Sulphur Trioxide	13.68	.798
Carbon Dioxide	216.00	12.597
Phosphorus Pentoxide	trace	trace
Chlorine	5.60	.327
Iron Sesqui-oxide and Alumina.....	2.62	.153
Lime	94.81	5.529
Magnesia	6.00	.350
Potash	3.78	.220
Soda	8.91	.520
<i>Probable Combinations</i>		
Potassium Chloride	6.00	.350
Sodium Chloride	4.53	.264
Sodium Sulphate	13.31	.776
Sodium Phosphate	trace	trace
Magnesium Sulphate	9.27	.540
Magnesium Carbonate	6.11	.356
Calcium Carbonate	169.30	9.873
Total Solids	231.46	13.498
Free Carbon Dioxide	137.31	8.008

The only large springs, visited by the writer in Laurens county, are situated on the right bank of the Oconee River, some miles south

of Dublin. These springs, locally known as the Well Spring, the Rock Spring and the Wilkes Spring, emerge as large streams, flowing several million gallons daily. The springs are from three to five miles apart; but they all are located within a few rods of the river, and near the contact of the Vicksburg-Jackson limestone and the Altamaha grit.

The domestic water-supply is obtained mainly from wells varying from 20 to 60 feet in depth. The wells obtain their water-supply from the Lafayette sands or the underlying Eocene or Miocene beds. The water is usually soft, and is considered quite wholesome.

LEE COUNTY

Lee county is noted for its numerous underground streams, which often appear at the surface in lime-sinks. When the channels of these underground streams become obstructed, the water frequently fills the lime-sinks along its course, and thus gives rise to a chain of ponds or small lakes. The waters of these ponds may disappear in a night, or they may remain an indefinite period. There are a few bold springs in the county, but none of very large size.

The main dependence for domestic water is shallow wells, which vary from 30 to 90 feet in depth. In recent years, these wells have been bored or driven. Wells of this class are usually short lived, unless properly cased. However, the cost is generally less than that of dug wells.

Successful deep wells have been sunk in Lee county at Leesburg, Smithville and Armena.

LEESBURG. — The Leesburg deep well was put down by the town in 1893, at a cost of about \$1,200.00. It is 540 feet deep, and it furnishes an abundant supply of water, which rises to within twelve feet of the surface. No record of the well was preserved. The character of the water, which is used for general domestic purposes, is shown by the following analysis, made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia: —

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	35.30	2.059
Sulphur Trioxide	11.26	.657
Carbon Dioxide	86.60	5.050
Phosphorus Pentoxide	trace	trace
Chlorine	5.25	.297
Iron Sesqui-oxide and Alumina.....	6.20	.362
Lime	37.00	2.158
Magnesia	5.60	.327
Potash	6.00	.350
Soda	35.92	2.095
<i>Probable Combinations</i>		
Potassium Chloride	9.40	.548
Sodium Chloride	1.19	.069
Sodium Phosphate	trace	trace
Sodium Sulphate	19.99	1.166
Sodium Carbonate	45.41	2.648
Calcium Carbonate	66.07	3.853
Magnesium Carbonate	11.76	.686
Iron Sesqui-oxide and Alumina.....	6.20	.362
Total Solids	195.32	11.391
Free Carbon Dioxide	32.52	1.897

Mr. W. M. Johnston's well, located on his plantation, two and a half miles west of Leesburg, has a depth of 150 feet, and it furnishes a flow six feet above the surface. Two water-bearing strata are reported, but only the second stratum furnishes a flow. The well is three inches in diameter, and flows about 18 gallons per minute. The flow is said to be somewhat reduced in dry seasons.

The following record has been furnished:—

Clay	from	0 to	9 ft.
Limestone	"	9 "	13 "
Cavity	"	16 "	24 "
Marl	"	24 "	104 "
Limestone with flint	"	104 "	144 "
Sand (water-bearing)	"	144 "	150 "

In addition to the well here described, Mr. Johnston also has three

other wells on his plantation, varying from 100 to 384 feet in depth, but none of these wells furnish a flow. The water is used only for general farm purposes.

SMITHVILLE.—(*Elevation, 319 feet above sea-level.*) There are four wells at Smithville, two of which belong to the Central of Georgia Railway, and two to the town. One of the railroad wells, which is three inches in diameter, attains a depth of 900 feet. Two water-bearing strata are reported in this well; one at 500, and the other at 900 feet. Water rises 20 feet above the surface. It is used to supply the railroad water-tank. The flow at the surface is about 50 gallons a minute.

Mr. G. W. Warwick, the well contractor, has furnished the following partial record:—

1 Clay and sand to.....	40 feet
2 Clay of various colors to.....	140 "
3 Cavernous rock (?) to.....	240 "
4 Blue clay with shells and sharks' teeth to.....	340 "
5 Limestone	345 "
6 Cavernous limestone with corals.....	(?)

At the bottom of the well, the drill struck very hard rock, that could not be penetrated.

Field analysis by Mr. W. W. Burnham, of the U. S. Geological Survey:—

<i>Constituents Determined</i>	<i>Parts per Million</i>
Chlorine	4.0
Total Carbonates, as Calcium Carbonate.....	91.0
Scale-forming Carbonates, as Calcium Carbonate.....	13.0
Alkali Carbonates, as Sodium Carbonate.....	82.6
Total Hardness, as Calcium Carbonate.....	—
Sulphur Trioxide (estimated)	5.0
Iron	trace
Odor, Hydrogen Sulphide	2.0
Turbidity	0.0
Color	0.0

The town wells, which have been recently completed, are said to be of the same depth as the Central of Georgia Railway well, above described.

ARMENA. — The deep wells at Armena, owned by Mr. I. P. Cocke, are three in number. They vary in depth from 290 to 450 feet. They are all non-flowing wells, and they were sunk chiefly to obtain water for plantation uses. The water rises to a varying height of from 24 to 68 feet of the surface.

Mr. Cocke gives the following record of one of his wells: —

Blue clay	from	0 to 40 ft.
Limestone	"	40 " 190 "
Quicksand	"	190 " 250 "
Flint (?)	"	250 " 280 "
Cavity, from which water rises to within 25 feet of the surface	"	280 " 290 "

The analysis of the water from this well, made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia, is as follows: —

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	9.20	.537
Sulphur Trioxide	4.90	.286
Carbon Dioxide	154.45	9.008
Phosphorus Pentoxide	trace	trace
Chlorine	6.32	.368
Iron Sesqui-oxide and Alumina	2.06	.117
Lime	84.40	4.922
Magnesia	1.10	.064
Potash .....	.90	.052
Soda	2.56	.149
<i>Probable Combinations</i>		
Potassium Chloride	1.42	.083
Sodium Chloride	4.83	.282
Sodium Phosphate	trace	trace
Calcium Carbonate	145.07	8.460
Calcium Sulphate	7.68	.448
Magnesium Sulphate .....	.57	.033
Magnesium Chloride	3.62	.211
Iron Sesqui-oxide and Alumina.....	2.06	.117
Total Solids	174.45	10.171
Free Carbon Dioxide	84.20	4.910



**PUTTING DOWN A DEEP WELL IN THE PINEY WOODS, NEAR DONALD-
SONVILLE, DECATUR COUNTY, GEORGIA.**



The upper water-bearing strata in the Lee county wells are Eocene, and the lower, probably Cretaceous.

LIBERTY COUNTY

The domestic water-supply of Liberty county is obtained largely from driven wells. These wells, which vary from 15 to 30 feet in depth, obtain their water from what appears to be Pliocene, or possibly, Pleistocene sands. Near the coast, it is said, that water in the wells is frequently struck at from 12 to 15 feet from the surface; but, unless they are extended beyond what is known as the first stratum of black rock, the water is unsatisfactory, owing to its containing fine sand. The water from these wells is soft, and is generally regarded as quite wholesome. There appears to be no springs of importance in the county. Successful deep wells have been sunk at Riceboro and Dorchester, and on St. Catherine's Island.

RICEBORO. — There are two Riceboro flowing-wells; one, 430, and the other, 460 feet deep. Water-bearing strata are reported at 350 and 450 feet, the latter stratum furnishing a flow, rising about 20 feet above the surface. The water is sulphureted, and is regarded as excellent for drinking purposes. Sand, clay, marl, and some thin layers of hard rock are said to have been penetrated in these wells; but their thickness and depth from the surface were not learned.

One of these wells, located at the station, supplies the water tank of the Seaboard Air Line Railway, by a natural flow. The analysis of the water from this well is as follows:—

Field analysis by Mr. W. W. Burnham, of the U. S. Geological Survey:—

	Parts per Million
Chlorine	6.5
Total Carbonates, as Calcium Carbonate.....	118.0
Scale-forming Carbonates, as Calcium Carbonate.....	21.0
Alkali Carbonates, as Sodium Carbonate.....	103.0

Total Hardness, as Calcium Carbonate.....	152.0
Sulphur Trioxide (estimated)	20.0
Iron	1.0
Odor, Hydrogen Sulphide	4.0
Color	0.0
Turbidity	0.0
Temperature (estimated)	70° F

The other Riceboro well, owned by Mr. A. E. Winn, and located on a plantation about one mile northeast of Riceboro station, is two-and-a-half inches in diameter, with a strong flow.

The water is used for general domestic and stock purposes. An analysis of it is as follows:—

Field analysis by Mr. W. W. Burnham, of the U. S. Geological Survey:—

<i>Constituents Determined</i>	<i>Parts per Million</i>
Chlorine	6.5
Total carbonates, as calcium carbonate.....	105.0
Scale-forming Carbonates, as Calcium Carbonate.....	—
Alkali Carbonates, as Sodium Carbonate.....	—
Total Hardness, as Calcium Carbonate.....	152.0
Sulphur Trioxide	33.0
Iron	0.5
Odor, Hydrogen Sulphide	4.0
Color	0.0
Turbidity	0.0
Temperature (estimated).....	78° F.

DORCHESTER. — Seven deep wells have been sunk in, or near, Dorchester. These wells, which are all flowing-wells, vary from 308 to 465 feet in depth. One of the wells, owned by Mr. W. P. Wait, located on his plantation two miles west of Dorchester, is six inches in diameter and 450 feet deep, and it furnishes 1,200 gallons per minute. The water, which is used for the irrigation of rice lands, rises 30 feet above the surface. Another well, owned by the same gentleman, but located in the village of Dorchester, is reported by Mr. Burnham to be three inches in diameter and 470 feet deep,

with a flow of about 100 gallons per minute. The field analysis of the water from the last named well is as follows:—

Field analysis by Mr. W. W. Burnham, of the U. S. Geological Survey:—

<i>Constituents Determined</i>	<i>Parts per Million</i>
Chlorine	6.5
Total Carbonates, as Calcium Carbonate.....	104.0
Scale-forming Carbonates, as Calcium Carbonate.....	0.0
Alkali Carbonates, as Sodium Carbonate.....	110.0
Total Hardness, as Calcium Carbonate.....	—
Sulphur Trioxide	42.0
Iron (estimated)	0.5
Odor, Hydrogen Sulphide.....	4.0
Turbidity	0.0
Color	0.0
Temperature (estimated)	78° F

ST. CATHERINE'S ISLAND. — The St. Catherine Island wells, owned by Mr. J. Raners, of Savannah, are five in number. They are said to attain an average depth of about 300 feet. They are three inches in diameter, and each furnishes a flow rising about 33 feet above the surface. The flow is said to be slightly affected by the tides, which cause a difference of pressure equal to a variation of about 18 inches in head. Four of these wells are cased to a depth of 200 feet, and have shown no perceptible variation in flow since their completion; while the fifth, cased to a much less depth, has become filled with sand, and has ceased to flow. The formations passed through are said to consist mainly of sand and marl, with a few thin layers of hard rock. The water, which is sulphureted, is used for general plantation purposes.

The deep wells of Liberty county seem to obtain their water-supply from the same geological horizon as the Brunswick wells.

LOWNDES COUNTY

The only springs of any importance in Lowndes county, known to the writer, occur in the Withlacoochee River. The domestic water-supply seems to be obtained almost entirely from shallow wells.

These wells obtain their water from the Lafayette or the underlying Miocene deposits. The water is considered quite wholesome; and, in the deeper wells it appears to be but little affected by droughts. In some instances, these wells are driven; but more frequently they are dug, and curbed with boards for part of their depth.

The only deep wells in Lowndes county are at Valdosta, the county seat. The first of these wells was completed in 1893, at a cost of about \$1,600.00. This well varies from 4½ to 10 inches in diameter, and is 522 feet deep. Mr. J. A. Durst, the well contractor, reports water-bearing strata at 260 (?), 460 and 515 feet, the water-bearing stratum in each case being a porous limestone. The water rises to within 113 feet of the surface.

Prof. H. C. White, Chemist, University of Georgia, has furnished the following analysis of the water from the different strata of the well:—

<i>Solids Dissolved</i>	Grains per U. S. Gallon		
	No. 1	No. 2.	No. 3.
Carbonate of Lime	5.524	4.726	5.429
Sulphate of Lime	0.763	0.654	0.813
Sodium Chloride	0.461	0.398	0.268
Sulphate of Soda	0.074	0.086	0.085
Sulphate of Potash	0.055	0.072	0.038
Sulphate of Magnesia	0.165	0.193	0.201
Oxide of Iron	0.101	0.096	0.121
Alumina	0.065	0.054	0.104
Silica	0.392	0.468	0.714
Organic Matter and Combined Water....	1.161	1.317	0.951
Nitrates	none	trace	trace
Total	8.761	8.055	8.724
Suspended Sediments	—	—	1.321

No. 1, from a depth of 360 feet.

No. 2, from a depth of 460 feet.

No. 3, from a depth of 515 feet.

A second well, put down by the city of Valdosta in 1900, has a depth of 500 feet, and is 8 inches in diameter. This well is said to furnish daily a maximum of 500,000 gallons of water, the capacity of the present pump, without perceptibly lowering the static head, which remains constant at 120 feet, from the surface. From a

series of borings from this well, together with some notes furnished by Mr. Dana Griffin, the Superintendent of the City Water-works, the following incomplete well record has been compiled:—

Superficial sand	from	0 to	2 ft.
Yellow sand	"	2 "	22 "
Sand and gravel	"	22 "	72 "
Blue marl	"	72 "	80 "
Soft coral rock	"	80 "	117 "
Sandy clay, often indurated and phosphatic.....	"	150 "	176 "
Rather compact, brownish gray limestone contain- ing minute grains of transparent quartz sand..	"	186 "	208 "
White porous limestone, water-bearing	"	240 "	260 "
Same as above, with fragments of sea-urchin...	"	325 "	360 "
White porous limestone, said to continue to bot- tom of well at.....			370 "

The analysis of the water from this well, made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia, is as follows:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	14.85	.866
Sulphur Trioxide	20.20	1.178
Carbon Dioxide	71.00	3.254
Phosphorus Pentoxide	trace	trace
Chlorine	5.44	.317
Iron Sesqui-oxide and Alumina.....	6.12	.357
Lime	34.94	2.038
Magnesia	5.19	.303
Potash	1.34	.078
Soda	3.85	.225
<i>Probable Combinations</i>		
Potassium Chloride	2.21	.139
Sodium Chloride	7.27	.424
Sodium Phosphate	trace	trace
Magnesium Sulphate	15.57	.908
Calcium Sulphate	16.69	.973
Calcium Carbonate	50.12	2.923
Iron Sesqui-oxide and Alumina	6.12	.357
Total	112.83	6.580
Free Carbon Dioxide	48.95	2.855

In addition to the wells here described, there are two or three other deep wells in Valdosta. These wells all obtain their water-supply apparently from the Eocene limestone. Fossils, brought up from 360 feet from the surface in the new well at the water-works station, have been identified by Dr. Dall as belonging to the Ocala or Peninsular limestone horizon.

MACON COUNTY

The deep wells of Macon county are located at Montezuma, Oglethorpe and Marshallville.

MONTEZUMA. — (*Elevation, 300 feet above sea-level.*) Montezuma has 18 flowing wells, varying from 60 to 500 feet in depth. Mr. E. J. Wilson, the contractor who put down several of these wells, gives the following record of the deepest well:—

1 Sand to	6 ft.
2 White clay to	18 "
3 Limestone to	20 "
4 Sand and clay to.....	50 "
5 Bluish tough clay to.....	60 "
6 Sand with mica to.....	75 "
7 Blue clay to.....	95 "
8 Sand and blue clay to.....	155 "
9 Fine, micaceous sand to	160 "
10 Sand and clay to	190 "
11 Sand with thin layers of flint to.....	310 "
12 Clay and fossil wood to	350 "
13 Limestone containing shells to	352 "
14 Micaceous sand to	356 "
15 Clay interstratified with sand to.....	416 "
16 Fossiliferous limestone with layers of sand to....	480 "
17 Clay to	496 "
18 Sand to	500 "

The first water-bearing stratum, struck at 60 feet, flowed eight feet above the surface; the second water-bearing stratum, struck at 150 feet, flowed 20 feet above the surface; the third water-bearing stratum, struck at 350 feet, flowed 30 feet above the surface; the fourth water-bearing stratum, struck at 500 feet, flowed 62 feet above the surface.

Three of the Montezuma wells obtain their water-supply from the first stratum, fourteen from the third, and one from the fourth. So abundant is the flow from the deep wells, that an attempt was made to use the water to furnish power to operate a cotton gin, but the attempt was not successful. The total amount of water furnished daily by these wells is very great; and it must necessarily cause a very heavy draught on the water-supply. Nevertheless, it is stated that there has not yet been any perceptible variation in the static head.

The following analysis by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia, was made from a sample of water taken from the city water-works reservoir, which is supplied with water from the fourth water-bearing stratum:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	39.98	2.846
Sulphur Trioxide	10.45	.610
Carbon Dioxide	36.80	2.150
Phosphorus Pentoxide	1.75	.102
Chlorine	6.80	.397
Iron Sesqui-oxide and Alumina.....	3.12	.182
Lime	18.50	1.079
Magnesia	2.50	.146
Potash	6.39	.373
Soda	29.07	1.695
<i>Probable Combinations</i>		
Potassium Chloride	10.12	.590
Sodium Chloride	3.26	.190
Sodium Sulphate	22.72	1.325
Sodium Phosphate	2.54	.148
Sodium Carbonate	27.92	1.628
Magnesium Carbonate	5.25	.306
Calcium Carbonate	33.03	1.926
Total Solids	137.94	8.043
Free Carbon Dioxide	7.92	.460

The following field analysis, made by Mr. W. W. Burnham, has

been furnished by Mr. M. O. Leighton, Chief of the Division of Hydro-Economics, U. S. Geological Survey:—

<i>Constituents Determined</i>	<i>Parts per Million</i>		
	I	II	III
Chlorine	4.0	4.0	6.5
Total Carbonates as Calcium Carbonate	25.4	32.2	36.2
Sulphur Trioxide	5.0	10.0	trace
Total Hardness, as Calcium Carbonate.	82.8	69	69
Iron	4.0	0.7	1.5
Odor, Hydrogen Sulphide.....	2.0	3	3
Color	46.0	0	0
Turbidity	0.0	0	0
Flow per Minute in Gallons.....	14.0	60	250
Temperature (estimated)	62° F.	60° F.	60° F.
Distance of strata from the surface....	60 ft.	350 ft.	500 ft.

OGLETHORPE. — The deep well at Oglethorpe, the county seat of Macon county, which was sunk by the town authorities in 1894, has a depth of 500 feet, and furnishes a strong flow. The strata penetrated in this well are said to be practically the same as in the Montezuma well.

The analysis of the water from the well, made by Prof. H. C. White, of the University of Georgia, is as follows:—

<i>Solids Dissolved</i>	<i>Grains per U. S. Gallon</i>
Sulphate of Lime	1.184
Sulphate of Soda	3.434
Sulphate of Magnesia	0.956
Chloride of Sodium	2.654
Carbonate of Soda	0.384
Carbonate of Lime	0.120
Silica	0.114
Organic Matter and Combined Water.....	0.430
Total	9.276

MARSHALLVILLE.—(*Elevation, 500 feet above sea-level.*) The deep well at this place, put down by the town council in 1901 at a cost of about \$1,200.00, has a depth of 397 feet. It is a 6-inch

well, reduced to 3 inches near the bottom; and it furnishes about 3,000 gallons per hour, the capacity of the pump. The water rises to within 121 feet of the surface.

Mr. M. N. Brewer, the well contractor, furnishes the following record of the Marshallville well:—

Yellow clay	from	1	to	25	feet
Sand with some pipe clay.....	"	25	"	90	"
Fine gray sand	"	90	"	185	"
Brownish sandy clay	"	185	"	230	"
Fine gray sand	"	230	"	270	"
Sand and blue marl	"	270	"	320	"
Clay	"	320	"	370	"
Thin layers of limestone	"	370	"	380	"
Very hard rock	"	380	"	390	"
Sand (water-bearing)	"	390	"	397	"

The following field analysis of the water from the Marshallville well, by Mr. W. W. Burnham, has been furnished by Mr. M. O. Leighton, Chief of the Division of Hydro-Economics, U. S. Geological Survey:—

<i>Constituents Determined</i>	<i>Parts per Million</i>
Chlorine	1.5
Total Carbonates as Calcium Carbonate.....	5.0
Sulphur Trioxide (estimated)	10.0
Total Hardness as Calcium Carbonate	41.4
Iron	2.0
Color	0.0
Odor of Hydrogen Sulphide.....	3.0
Turbidity (estimated)	5.0
Temperature (estimated)	61° F.

With the exception, probably, of the upper water-bearing strata in the Oglethorpe and Montezuma wells, the water-supply of the deep wells of Macon county appear to come from the Upper Cretaceous.

No springs of any importance are reported in the county. The domestic water-supply is secured chiefly from shallow wells varying from 20 to 60 feet in depth. The water of these wells, which is obtained mainly from the Lafayette sands and clays, is soft, and is usually considered wholesome.

MARION COUNTY

Marion county is fairly well supplied with small springs; but the main reliance for domestic water-supply is shallow wells. These wells obtain their water from the Lafayette sands and clays, or the underlying Cretaceous beds. The former source of water is usually more satisfactory than the latter, owing to the absence of lime.

The only deep well, reported in Marion county, is located at Buena Vista, the county-seat. This well is ten inches in diameter and 583 feet deep. The water rises to within 240 feet of the surface. Mr. E. J. Wilson, the well contractor, gives the following record of the Buena Vista well:—

Blue clays	from	0	to	35	ft.
Sand and clays	"	35	"	105	"
Soft limestone	"	105	"	155	"
Marl	"	155	"	158	"
Rock	"	158	"	159	"
Marl	"	159	"	252	"
Flint	"	252	"	254	"
Indurated marl	"	254	"	263	"
Hard rock	"	263	"	270	"
Marl	"	270	"	297	"
Limestone (water-bearing)	"	297	"	331	"
Coarse, gray sand	"	331	"	343	"
Marl (water-bearing)	"	343	"	364	"
Marl	"	364	"	551	"
Hard, compact rock	"	551	"	583	"

Two water-bearing strata are reported in the well, one at 331, and the other at 364 feet from the surface. The first of these beds is said to have yielded a large quantity of water; but it was found impossible to keep the bore-hole from filling with quicksand. Several weeks were spent in trying to control the inflowing sand; but all efforts were unsuccessful. The quicksand was finally cased off, and the well was continued to the depth of 583 feet, when the appropriation made by the town council was expended, and the well was abandoned. The water-bearing strata of this well are Cretaceous.

MITCHELL COUNTY

Springs are reported at various points in the western part of Mitchell county along the Flint River; but none of them appear to be of very large size. The main dependence for domestic water-supply is shallow wells. Successful deep wells have been sunk at Camilla and Pelham. The well at the former place is said to be 600 feet deep, while the latter is only 293 feet deep. The Pelham well, which is only two and a half inches in diameter, is said by the Mayor to have penetrated the following strata:—

Red and yellow clays	from	0	to	25	ft.
Yellow clays with thin layers of sand.....	"	25	"	155	"
Limestone with varying degrees of hardness....	"	180	"	293	"

This well and also the deep well at Camilla obtain their water-supply, no doubt, from the Vicksburg-Jackson limestone.

McINTOSH COUNTY

McIntosh county has a number of deep wells, all of which are flowing. They furnish an abundant supply of sulphureted water. These wells vary from about 400 to 550 feet, and, apparently, they obtain their water-supply from the same horizon as the Liberty and the Glynn county wells.

DARIEN.—The first attempt to obtain artesian water at Darien was made in 1885, by sinking a four-inch well to the depth of 492 feet. This well supplied the town with water, until 1891, when the large eight-inch well, now in use, was completed. The eight-inch well is 530 feet deep. It flows about 200 gallons per minute. The water is hard and sulphureted, but quite wholesome. It rises 15 feet above the surface. The main water-bearing stratum is said to be near the bottom of the wells. Other strata are reported nearer the surface, though the flow is unsatisfactory.

The following notes were made from a partial series of borings obtained from the county ordinary:—

Very coarse sand and pebbles. The pebbles, which consist of both quartz and feldspar, are only slightly rounded, and are often incrustated with a yellowish ochreous deposit at.....	125	feet
Dark-gray marl, having a greenish tint, and containing numerous microscopic rhombohedral crystals of calcite, at	133(?)	"
Very fine, gray sand with considerable clay; also a few large, well-rounded quartz grains, at.....	143	"
Fine brown sandy clay and fragments of shells, at....	167	"
Coarse sand, pebbles and fragments of shells, at.....	176	"
The same as the above, except that it contains glauconite, at	188	"
Gray marl, made up largely of minute crystals of calcite with a few grains of coarse sand, at.....	220	"
Fine, gray, micaceous sand and a few fragments of shells, at	221	"
Diatomaceous earth, of a greenish gray color, at.....	258	"
Diatomaceous earth, with a few small crystals of selenite, at	280	"
Diatomaceous earth, in which spicules of sponges are common, at	330	"
Diatomaceous earth and a few particles of glauconite, at.....	350	"
Diatomaceous earth at	375	"
Coarse sand and pebbles forming conglomerate, which contains sharks' teeth, small dental plates (possibly of the ray), fragments of shells, and pieces of lignite, the last often an inch in diameter, at.....	385	"
Rather fine, gray sand, with sharks' teeth, glauconite, a few diatoms, and fragments of bone and shell, at....	388	"
Indurated, highly calcareous light-gray marl resembling chalk, at	391	"
Fine, dark-gray sand containing small flakes of mica, diatoms, spicules of sponges and glauconite, at.....	400	"
Fine, yellow sand, with fragments of shells, glauconite and diatoms, at	420	"
Hard, compact greenish clay, breaking with conchoidal fracture, at	440	"
The same as the above at.....	500	"
Fine, dark-gray glauconitic sand, at.....	515	"
The same as the above, except with fragments of shells, at	524	"
Hard, compact clay-stone and sand, at.....	530	"

The following field analysis of the water from the Darien well, made by Mr. W. W. Burnham, has been furnished by Mr. M. O. Leighton, Chief of the Division of Hydro-Economics, U. S. Geological Survey:—

<i>Constituents Determined</i>	<i>Parts per Million</i>
Chlorine	11.5
Total Carbonates, as Calcium Carbonate	125.0
Scale-forming Carbonates, as Calcium Carbonate.....	0.0
Alkali Carbonates, as Sodium Carbonate.....	125.0
Total Hardness, as Calcium Carbonate.....	179.0
Sulphur Trioxide	93.0
Iron	1.0
Color	0.0
Odor, Hydrogen Sulphide	3.0
Turbidity	0.0
Temperature (estimated)	72° F.

BARRINGTON. — The deep well at Barrington, sunk by the Atlantic Coast Line Railroad in 1895, for the purpose of securing water to supply its locomotives, is three inches in diameter and 450 feet deep. It furnishes 200 gallons of water per minute, and the water rises 20 feet above the surface. Two flows are reported in the well, one at 350 feet, and the other at 450 feet. The formations penetrated are said to be similar to those in the Brunswick wells.

The following field analysis of the water from the Barrington well was made by Mr. W. W. Burnham and furnished by Mr. M. O. Leighton, Chief of the Division of Hydro-Economics, U. S. Geological Survey:—

<i>Constituents Determined</i>	<i>Parts per Million</i>
Chlorine	11.5
Total Carbonates, as Calcium Carbonate	113.0
Scale-forming Carbonates, as Calcium Carbonate	8.0
Alkali Carbonates, as Sodium Carbonate	111.0
Total Hardness, as Calcium Carbonate	178.0
Sulphur Trioxide	105.0
Iron	0.5
Color	0.0
Turbidity	0.0
Odor, Hydrogen Sulphide	3.0
Temperature (estimated)	72° F

WOLF ISLAND. — This well was completed in 1891, at a cost of \$500. It is a two-inch well, 500 feet deep. The water, which is strongly sulphureted, rises 45 feet above the surface. No record of the well has been preserved.

CREYTON ISLAND. — The Creyton Island well, owned by Mr. George E. Atwood, has a depth of 414 feet. It is three inches in diameter, and furnishes a flow which rises 50 feet above the surface. A dark colored rock, 20 feet in thickness, is reported to have been struck in this well at 320 feet. Samples of this rock, forwarded to the writer by Mr. Atwood, were found to be impure manganese ore. Coral rock and beds of gravel are said to have occurred in the well; but neither their depth nor their thickness was given.

DOBOY. — Mr. J. C. Woodhull's well at Doboy is 128 feet deep, and furnishes a flow which rises 10 feet above the surface. This well is interesting, as it is the only deep well in the county where a flow is obtained near the surface. The water-bearing stratum furnishing this flow probably occurs in other deep wells in the county; but its presence has not been reported.

In addition to the deep wells here described, there are also deep wells at Inwood and Ridgeville, and on Union and Sapelo Islands.

McIntosh county appears to have but few springs. Shallow wells are the chief reliance for the domestic water-supply.

MONTGOMERY COUNTY

No information has been received concerning the distribution of springs in Montgomery county. Springs, no doubt, occur in this county in considerable numbers. However, judging from the character of the underlying formations, they are probably small and of but little importance. Shallow wells are to be found at nearly every farm house. They vary from 20 to 50 feet in depth, and furnish an abundance of water for all domestic purposes. The only deep wells reported in the county are at McArthur, Higgston and Ochwalkee.

MCARTHUR.—(*Elevation, 247 feet above sea-level.*) The McArthur well is three inches in diameter and 900 feet deep. Water rises

to within 60 feet of the surface. Mr. J. B. Spencer has kindly furnished the following record of the well:—

Sandy soil	from	0	to	4	ft.
Red clay	"	4	"	20	"
Coarse sand	"	20	"	30	"
Blue clay with thin layers of sandstone.....	"	30	"	250	"
Sand	"	250	"	350	"
Limestone with some water	"	350	"	500	"
Flint	"	500	"	502	"
Sandstone	"	502	"	525	"
Shell formation	"	525	"	625	"
White limestone	"	625	"	890	"

Water-bearing strata are reported in this well at 419 and 890 feet. The water from both strata is said to have about the same static head.

HIGGSTON. — Mr. T. M. Barker's well at this place was completed in 1902. It is six inches in diameter and 353 feet deep. The water rises to within 73 feet of the surface. No record of the well has been secured. The water-bearing stratum probably occurs near the bottom of the well, and corresponds possibly with the second water-bearing stratum of the McArthur well.

OCHWALKEE. — The deep well at Ochwalkee, owned by the Hilton & Dodge Lumber Company, is 228 feet deep and three inches in diameter. It has a flow of 25 gallons per minute. The water, which is used chiefly for domestic purposes, rises 20 feet above the surface. No record of the well was secured.

The source of the water, supplying the deep wells of Montgomery county, seems to be Eocene limestones; while the shallow wells obtain their water-supply from the Lafayette, or the underlying Altamaha formation.

MUSCOGEE COUNTY

The main source of domestic water-supply of Muscogee county is shallow wells, which vary from 20 to 60 feet in depth. The water of these wells is obtained largely from the superficial Lafayette.

However, in the absence, or thinning, of this deposit, the wells obtain their water from the underlying Cretaceous sands and clays. The water of these shallow wells is usually soft, and is regarded as quite wholesome.

The springs of the county are small and few in number. They are often met with, along the larger streams and near the margins of the river and creek valleys. Springs of this character are to be seen along the banks of the Chattahoochee River, within the corporate limits of Columbus; and also along the second river terrace east of the city. These springs rarely ever furnish more than five or ten gallons of water per minute; and they are more or less affected by drought.

The only successful deep well in Muscogee county is located on the Bass plantation, about four miles south of Columbus, near the mouth of Bull Creek. This well is three inches in diameter and 425 feet deep. The water rises four feet above the surface. The only water-bearing stratum reported in the well occurs at about 400 feet from the surface. When the well was first completed, it is said to have flowed between 90 and 100 gallons per minute; but, at present, the flow is only about two-thirds this amount. This decrease in flow is thought to be due to the filling of the casing with sand.

The source of the water supplying the Bass well is supposed to be the base of the Cretaceous. However, as the well is within less than three miles of the Crystalline rocks, it is not at all improbable that the source may be the upper part of the decomposed gneisses and schists, upon which the Cretaceous beds have been deposited.

PIERCE COUNTY

The only deep well reported in Pierce county is at Offerman. This well, owned by the Southern Pine Company of Georgia, is located on the west side of the Atlantic Coast Line Railroad, almost a quarter of a mile north of the Atlanta, Birmingham & Atlantic Railroad junction. The well was put down in 1898 at a cost of \$500. It is eight inches in diameter and 125 feet deep. Originally, the well was 515 feet deep, but it subsequently filled with sand to 125 feet. The water, which is used for boiler purposes and for drinking, rises to



A RICE MILL, AT TARHOKO, CAMDEN COUNTY, GEORGIA, OPERATED BY ARTESIAN WELLS.



within 108 feet of the surface. The maximum yield of the well is 40 gallons per minute. Rock is reported at 98 and 500 feet from the surface, the former bed extending to 108 feet, at which point water-bearing sand was struck.

The above notes, together with the following field analysis of the water, have been furnished this Survey by Mr. W. W. Burnham:—

<i>Constituents Determined</i>	<i>Parts per Million</i>
Chlorine	9.0
Total Carbonates, as Calcium Carbonate	96.4
Scale-forming Carbonates, as Calcium Carbonate.....	—
Alkali Carbonates, as Sodium Carbonate.....	—
Total Hardness, as Calcium Carbonate	124.0
Sulphur Trioxide (estimated)	5.0
Odor, Hydrogen Sulphide	2.0
Iron	0.5
Color	0.0
Turbidity	0.0
Temperature (estimated)	65° F.

Pierce county has no springs of importance. Shallow wells are the principal source of domestic water-supply.

PULASKI COUNTY

Shallow wells seem to be the main source of domestic water-supply in Pulaski county. There is no doubt, that there are numerous springs in the county; but no information has been received concerning their location and ownership. Deep wells have been put down at Hawkinsville and Cochran.

HAWKINSVILLE.—(*Elevation, 235 feet above sea-level.*) There are a number of deep wells within the corporate limits of Hawkinsville, five of which belong to the city. These wells, which vary from two to eight inches in diameter, attain a depth from 300 to 500 feet. Two water-bearing strata were struck in the deeper wells at 265 and 490 feet from the surface. Both strata furnish flowing water, which is hard and slightly sulphureted. The water from the second stratum rises about 12 feet above the surface.

The following record of one of the Hawkinsville wells is given by Mr. Dearing, a well contractor:—

Red and yellow clays	from	0 to	40 ft.
Limestone with layers of blue clay.....	"	40 "	180 "
White limestone and clay	"	180 "	220 "
Blue clay	"	220 "	260 "
Coarse water-bearing sand containing sharks' teeth	"	260 "	360 "
Limestone interstratified with clay	"	360 "	490 "
Coarse water-bearing sand at.....			490 "

The following analysis by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia, was made from the water from the second stratum:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	30.80	1.796
Sulphur Trioxide	7.12	.357
Carbon Dioxide	137.80	9.786
Phosphorus Pentoxide	trace	trace
Chlorine	18.20	1.051
Iron Sesqui-oxide and Alumina.....	5.30	.309
Lime	86.70	5.058
Magnesia	3.60	.210
Potash	4.41	.257
Soda	22.26	1.298
<i>Probable Combinations</i>		
Potassium Chloride	6.99	.408
Sodium Chloride	24.40	1.423
Sodium Sulphate	13.31	.776
Sodium Phosphate	trace	trace
Sodium Carbonate	6.02	.351
Magnesium Carbonate	7.56	.441
Calcium Carbonate	154.82	9.006
Total solids	249.20	14.533
Free Carbon Dioxide	63.22	3.687

COCHRAN.—(*Elevation, 341 feet above sea-level.*) The Cochran deep well, completed in 1895, is six inches in diameter and 365 feet

deep. The water rises to within 85 feet of the surface. It is hard and sulphureted, and is used for general domestic purposes. The only water-bearing stratum reported is at 350 feet. The record of the well is said to be similar to that of the Hawkinsville well.

RANDOLPH COUNTY

Large limestone springs are said to be common in Randolph county in the limestone districts. A spring of this nature may be seen in Greer's Cave, an interesting limestone cavern located in the northern part of the county. Small springs are numerous; but the main source of the domestic water-supply is shallow wells. These wells, which vary from 30 to 50 feet in depth, usually furnish an abundant supply of soft water throughout the year. The only deep wells in the county are at Cuthbert and Shellman.

CUTHBERT.—(*Elevation, 432 feet above sea-level.*) The Cuthbert deep well, sunk some years ago by the town of Cuthbert to obtain water for domestic purposes, is said to attain a depth of 1,000 feet. It varies from four to six inches in diameter. The only information secured concerning the Cuthbert well is contained in the following meagre notes by Dr. J. W. Spencer, former State Geologist of Georgia¹:—

"This well was sunk to a depth of 1,000 feet, but the record was not kept. From a point between 340 and 400 feet, water rose to within 30 feet of the surface; and at 550 feet, the water rose to within 70 feet of the surface."

The Cuthbert well is now abandoned. However, there seems to be no reason why it could not be used to supply the town with water.

SHELLMAN.—The deep well at Shellman, which supplies the town with water, was completed in 1902. It is six inches in diameter and 410 feet deep. The only water-bearing stratum reported occurs near the bottom of the well. The water rises to within 70 feet of the surface. Mr. J. E. Cole, the well contractor, has kindly furnished the following record:—

¹ Geological Survey of Georgia, First Report of Progress, p. 79, 1850.

Red clay	from	0 to	18 ft.
Quicksand	"	18 "	148 "
Blue marl	"	148 "	300 "
Very hard limestone	"	300 "	400 "
Water-bearing formation	"	400 "	410 "

From specimens furnished by Mr. Cole, the writer has made the following additional notes:—

Green, sandy, glauconitic marl.....	250 feet
The same as above, but with more sand	350 "
Quartzose and calcareous sand	400 "

The following analysis of the water was made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	27.02	1.576
Sulphur Trioxide	10.20	.595
Carbon Dioxide	93.50	5.453
Phosphorus Pentoxide	trace	trace
Chlorine	5.40	.317
Iron Sesqui-oxide and Alumina	4.62	.269
Lime	65.69	3.831
Magnesia	2.39	.139
Potash	2.33	.136
Soda	6.54	.381
<i>Probable Combinations</i>		
Potassium Chloride	3.69	.215
Sodium Chloride	6.06	.353
Sodium Sulphate	7.33	.427
Sodium Phosphate	trace	trace.
Magnesium Sulphate	7.17	.418
Calcium Sulphate	1.90	.111
Calcium Carbonate	115.91	6.757
Total Solids	173.70	10.130
Free Carbon Dioxide	42.50	2.479

The water-bearing strata of the Cuthbert and Shellman wells appear to be lower Eocene, or possibly Upper Cretaceous.

RICHMOND COUNTY

There are said to be several deep wells in Richmond county, all of which are located in or near the corporate limits of Augusta.

One of these wells, owned by the Georgia Chemical Company, attains a depth of 897 feet. It is six inches in diameter, and is said to penetrate the following water-bearing strata or seams:—

1 Between 150 and 190 feet, water rising to within 90 feet of surface.

2 Between 200 and 300 feet, water rising to within 80 feet of surface.

3 Between 500 and 600 feet, water rising to within 75 feet of surface.

4 Between 600 and 700 feet, water rising to within 75 feet of surface.

5 Between 800 and 900 feet, water rising to within 45 feet of surface.

Water from the fourth water-bearing stratum is said to be somewhat brackish; while that obtained from the other strata is hard and slightly chalybeate. The greater part of this well was driven in hard, compact crystalline rock. The first water-supply is probably obtained near the base of the Cretaceous sands and gravels, overlying the Crystalline schists and gneisses.

The Arsenal deep well in Summerville, a suburb of Augusta, is 814 feet deep and eight inches in diameter. It is thus described by Capt. D. M. Taylor, of the Ordnance Department, U. S. A.:—

“Three water-bearing strata were struck in the well at 500, 600 and 700 feet, respectively. As much as 1,080 gallons per hour have been pumped from the well without perceptibly lowering the static head. The water is hard and slightly chalybeate. The first 85 feet passed through consisted of sand, red clay and gravel. Hard chloritic slate was reached at 280 feet, which was followed by a similar rock, with occasional thin layers of quartz, to 700 feet. The rock varies in hardness, occasionally being comparatively soft, but generally very hard and tough, the softer rock being met with imme-

diately above the water courses and including them, and the hardest immediately below these water courses. Near the bottom of the well was found a greenish quartz rock."

Capt. Taylor is of the opinion, that there is another water-bearing stratum not noted above, between 150 and 200 feet. This belief, he bases on the fact, that there are several wells in the city and one at the arsenal, which are supplied with water from this depth. In a letter to the writer, Capt. Taylor says of these wells: — "I have one at the Arsenal, from which the main supply of water is now obtained. It is about 160 feet deep, and five or six feet in diameter, and the water stands in it at a constant depth of between $9\frac{1}{2}$ and 11 feet, not varying at all, from local rains or droughts. It is usually pumped dry every day, and fills again for the next day's pumping. This water I consider much better than that from the artesian well."

All the deep wells in Augusta and vicinity obtain their water-supply from the sand beds at the base of the Cretaceous, or from fissures and seams in the underlying Crystallines.

CHAPTER IX

DETAILED DESCRIPTION OF THE UNDERGROUND WATERS OF THE COASTAL PLAIN (*Concluded*)

SCHLEY COUNTY

The domestic water-supply of Schley county is obtained mainly from shallow wells varying from 20 to 70 feet in depth. The water is usually soft and well suited to manufacturing purposes. The most common source of the water is the Lafayette sands. Some of the deeper wells, no doubt, penetrate the upper beds of the underlying Cretaceous; but such wells are probably confined chiefly to the valleys or low-lands, where the Lafayette sands and clays have been removed.

The springs of Schley county are small, but quite abundant. They are confined mostly to the heads of small runs, where the Cretaceous beds are exposed. These waters may be either hard or soft, depending upon the character of the beds from which they flow. Occasionally the waters from these springs carry iron oxide. A spring of this character is to be seen on the Burtz farm, three and a half miles east of Ellaville. On the same farm, also, occurs a bold limestone spring, furnishing 20 gallons or more per minute. No attempt has, so far, been made in Schley county to secure water by deep borings.

SCREVEN COUNTY

Screven county has several deep wells, which are located at Millen, Rocky Ford, Dover, Sylvania and Scarboro. All these wells apparently obtain their water-supply from the Vicksburg-Jackson limestone.

MILLEN. — (*Elevation, 157 feet above sea-level.*) The Millen wells, seven in number, vary from 320 to 500 feet in depth. They are from four to six inches in diameter, and all furnish flows, rising

from three to twenty feet above the surface. The deeper wells are said to have penetrated water-bearing strata at 260, 300 and 390 feet, and between 450 and 500 feet.

Mr. H. F. Loyd, the well contractor, reports red and yellow clays to the depth of 90 feet, beneath which, and extending to the bottom of the wells, occur bluish marls interlaminated with beds of limestone varying from two to sixteen feet in thickness.

Lignite and pyrite are also reported in the wells; but their depth from the surface could not be ascertained. The water from all of the wells is used for general domestic and boiler purposes. It has a very decided odor of hydrogen sulphide. This odor, however, disappears, upon the water being exposed a short time to the air.

The character of the water obtained from one of these wells located a few rods from the railroad station is shown by the following analysis by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	38.00	2.216
Sulphur Trioxide	9.49	.553
Carbon Dioxide	92.20	5.377
Phosphorus Pentoxide	trace	trace
Chlorine	8.00	.466
Iron Sesqui-oxide and Alumina.....	1.25	.073
Lime	56.38	3.288
Magnesia	6.00	.350
Potash	2.99	.174
Soda	7.49	.437
<i>Probable Combinations</i>		
Potassium Chloride	4.75	.277
Sodium Chloride	8.24	.481
Sodium Phosphate	trace	trace
Sodium Sulphate	7.13	.416
Magnesium Sulphate	8.24	.481
Magnesium Carbonate	6.82	.398
Calcium Carbonate	100.67	5.871
Iron Sesqui-oxide and Alumina	1.25	.073
Total Solids	175.10	10.212
Free Carbon Dioxide	44.34	2.586



BLUE SPRING, FOUR MILES SOUTH OF ALBANY, DOUGHERTY COUNTY, GEORGIA.



ROCKY FORD. — (*Elevation, 117 feet above sea-level.*) Rocky Ford has seven deep wells, each attaining a depth of about 180 feet and furnishing a flow, rising 15 feet above the surface. All these wells, which are said to be four inches in diameter, have been put down in the last ten years at an average cost of about \$200 each. The water is sulphureted, and contains calcium carbonate, magnesium salts and other mineral matter. The first flow is said to have been obtained at 100 feet from the surface, gradually increasing to the bottom of the wells. Sand, clay, marl, and five or six beds of hard rock, probably limestone, are reported to have been penetrated, in sinking these wells.

The following field analysis of the water from the Rocky Ford town well, made by Mr. W. W. Burnham, has been furnished by Mr. M. O. Leighton, Chief of the Division of Hydro-Economics, U. S. Geological Survey:—

<i>Constituents Determined</i>	<i>Parts per Million</i>
Chlorine	6.5
Total Carbonates, as Calcium Carbonate	115.0
Scale-forming Carbonates, as Calcium Carbonate.....	19.7
Alkali Carbonates, as Sodium Carbonate.....	101.0
Total Hardness, as Calcium Carbonate.....	124.0
Sulphur Trioxide	present
Iron (estimated)	0.5
Odor, Hydrogen Sulphide	3.0
Color	0.0
Turbidity	0.0
Temperature (estimated)	68° F.

SYLVANIA. — There are two wells at Sylvania, one of which is owned by Mr. T. A. Marks, and the other by Mr. L. H. Hilton. The former well, located in a valley just below the post-office, was put down in 1895, at a cost of \$900. It is four inches in diameter and 697 feet deep; and it furnishes a maximum of 50 gallons of water per minute. The water rises to within 70 feet of the surface; and it is used for general domestic purposes. Hard rock, 30 feet thick, is reported at 200 feet from the surface. The following field analysis of water from the Marks well, together with the above

notes on this well, were furnished by Mr. W. W. Burnham, of the United States Geological Survey:—

<i>Constituents Determined</i>	<i>Parts per Million</i>
Chlorine	4.0
Total Carbonates, as Calcium Carbonate	93.1
Scale-forming Carbonates, as Calcium Carbonate.....	0.0
Alkali Carbonates, as Sodium Carbonate.....	99.3
Total Hardness, as Calcium Carbonate.....	125.0
Sulphur Trioxide	trace
Iron	1.0
Odor	chalky
Color	0
Turbidity	0
Temperature (estimated).....	68° F.

Mr. L. H. Hilton's well, which Mr. Burnham reports as unsuccessful, was put down in 1895, at a cost of \$350. The well is 3 inches in diameter, and 285 feet deep. The water rises to within 80 feet of the surface. The only water-bearing stratum, reported, occurs at 280 feet. The following record is furnished:—

- 1 Red clay 60 feet
- 2 Light-colored clay 100 "
- 3 Thin layers of hard rock, interlaminated with coarse black sand to the bottom of the well.

SCARBORO. — (*Elevation, 157 feet above sea-level.*) The Scarborough well, owned by Mr. M. C. Sharpe, was put down by Mr. H. F. Loyd in 1902, at a cost of \$650. The well is four inches in diameter, and 505 feet deep. The water rises to within 15 feet of the surface. Water-bearing strata are reported at 180 and 300 feet; but the main supply is said to come from a depth of 375 feet. The well is located in the public square of the town, and the water is used for drinking and general domestic purposes. The following incomplete record is given:—

- 1 Sand 4 feet
- 2 Blue marl 100 "
- 3 Soft rock with cavities 40 "
- 4 Hard rock at 200 feet extending to bottom of well.

A field analysis by Mr. W. W. Burnham, of the United States Geological Survey, is as follows:—

<i>Constituents Determined</i>	Parts per Million
Chlorine	11.5
Total Carbonates, as Calcium Carbonate.....	112.3
Scale-forming Carbonates, as Calcium Carbonate.....	8.8
Alkali Carbonates, as Sodium Carbonate.....	110.0
Total Hardness, as Calcium Carbonate.....	125.0
Sulphur Trioxide	slight trace
Iron ¹	1.5
Odor, Hydrogen Sulphide	3.0
Color	0.0
Turbidity	0.0
Temperature (estimated)	70° F.

DOVER. — This well, which was completed in February, 1903, by the Central of Georgia Railway, at a cost of \$300.00, is three inches in diameter, and 350 feet deep. The water rises 19 feet above the surface. Water-bearing strata are reported at 125 and 225 feet, both of which furnish flows. The water is used chiefly for steam purposes by the Central of Georgia Railway.

An analysis of this water, made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia, is as follows:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	49.88	2.910
Sulphur Trioxide	3.26	.190
Carbon Dioxide	97.40	5.680
Chlorine	29.22	1.702
Iron Sesqui-oxide and Alumina.....	4.19	.244
Lime	49.80	2.904
Magnesia	10.31	.601
Potash	8.55	.496
Soda	27.00	1.574
<i>Probable Combinations</i>		
Potassium Chloride	13.55	.790
Sodium Chloride	37.51	2.187
Sodium Phosphate	trace	trace
Sodium Sulphate	5.79	.338

¹ Some of the iron may have come from the casing.

<i>Probable Combination</i>	Parts per Million	Grains per U. S. Gallon
Sodium Carbonate	7.86	.458
Magnesium Carbonate	21.65	1.262
Calcium Carbonate	88.93	5.186
Iron Sesqui-oxide and Alumina.....	4.19	.244
Total Solids	229.36	13.378
Free Carbon Dioxide	43.67	2.547

With the exception of the towns above referred to, the main source of domestic water-supply of Screven county is shallow wells. There are a few springs reported in the county; but, in most cases, they are said to be located in the swamps along the Savannah River, and are subjected to overflow during freshets.

STEWART COUNTY

The chief source of domestic water-supply in Stewart county is shallow wells. The water, which supplies these wells, is usually soft, and is said to be quite wholesome. In most instances, it is probable, that these shallow wells obtain their water from the Lafayette sands; but the deeper ones, no doubt, penetrate the underlying Cretaceous beds. There are numerous springs in Stewart county; but they are usually small, and are located in the heads of deep ravines or along streams, thus being more or less inaccessible, or liable to overflow during freshets. Lumpkin, the county-seat, is supplied from springs of this character. The partial chemical analysis of water from Lumpkin springs, furnished by the Mayor, shows that the water is very pure, having less than two grains of mineral matter per gallon.

The only deep wells, reported in Stewart county, are located on the Bradley plantations near the Chattahoochee River, and at Richland. Three of the wells, owned by Mr. W. C. Bradley, vary in depth from 290 to 315 feet. They are three inches in diameter; and they furnish flows from 3 to 20 feet above the surface. No hard rock is reported in the wells, the formations being clay, marl and sand. The water-supply from each of these wells comes apparently from the same stratum. Notwithstanding this, the quality of the water is said to be entirely different. The water from well No. 1

contains sulphur and iron; from well No. 2, sulphur; and from well No. 3, magnesia. The water is used for general domestic purposes.

In addition to these flowing wells, Mr. W. C. Bradley reports two non-flowing wells on his plantation. One of them was continued to the depth of 715 feet; but no increase of static head was obtained below the 315-foot level, at which point the water rose to within 16 feet of the surface. Both of these wells are now supplied with pumps, and they furnish all the water necessary for farm purposes.

Another well in the same vicinity, owned by Mr. Daniel Bradley, located on more elevated ground, is reported to attain a depth of 740 feet. This is a non-flowing, 3-inch well, furnishing water highly charged with hydrogen sulphide. The water-bearing stratum is said to have been struck in this well at 475 feet. Mr. Bradley has kindly furnished the following well record:—

1	Clay	12 feet
2	Sand	60 "
3	Marl, with an occasional stratum of hard rock, to the bottom of the well.	

RICHLAND.—(*Elevation, 680 feet above sea-level.*) The Richland well, which was put down in 1898, is six inches in diameter, and 425 feet deep. The water rises to within 100 feet of the surface, or 580 feet above sea-level. The supply, which is 50 gallons a minute, is used for drinking and general domestic purposes. Hard rock is reported at 300 feet. Besides the well here described, an unsuccessful attempt was made at Lumpkin, the county seat; but no data were secured concerning the well.

All the deep wells in Stewart county obtain their water-supply from Cretaceous sands.

SUMTER COUNTY

Shallow wells are the main source of domestic water-supply in Sumter county. They vary from 20 to 70 feet in depth, and obtain their water-supply mainly from either the Lafayette sands or the

underlying Eocene beds. The latter beds are often calcareous, and furnish what is generally reported as unwholesome water.

There are many springs in Sumter county, none of which, however, are of very large size. Among those, which may be mentioned as of some local importance, on account of being favorite resorts for summer picnics and fishing parties, are Holly Spring, Myrtle Spring, Magnolia Spring, Summerford's Spring and Providence Spring. The last named spring, which was located within the stockade of the old Confederate prison at Andersonville, has more than a local reputation, on account of its association with the famous Andersonville prison and its supposed origin. The story is told, that this spring had no existence prior to the construction of the prison; but that it burst forth one night after a hard rain, in answer to the prayers of the Federal soldiers. The spring is a small one, furnishing only a few gallons a minute. It is located near the base of the elevated ground, on which the prison stockade was erected. Its origin at the opportune time, which seemed to be a special act of Providence, is accounted for by the heavy night rain, which washed away the overlying clays and sands, and exposed the underlying water-bearing stratum. Springs of similar origin are frequently met with, in deep washouts or gulleys, where the overlying sandy Lafayette clays have been cut away to some impervious clay. The geologic conditions in the vicinity of Andersonville are especially well adapted to the origin of springs of this character.

The deep wells of Sumter county are located at Americus, Huguenin, Andersonville, Old Danville, Leslie, DeSoto and Bagley.

AMERICUS. — (*Elevation, 348 feet above sea-level.*) Five deep wells are reported within the corporate limits of Americus. Three of these wells, supply the city waterworks, one, the Windsor hotel, and the other, the water-tank at the Central of Georgia Railway station.

The Windsor hotel well, which is said to attain a depth of 1,725 feet, was put down in 1883. It varies from four to eight inches in diameter. Several water-bearing strata are reported in this well; but only the one at about 1,000 feet had sufficient head to bring the water to within 30 feet of the surface.

The city wells are four and six inches in diameter, and vary from 258 to 670 feet in depth. These wells are located on lower ground than the Windsor well; and, as a consequence, the water stands nearer the surface by 20 feet.

Dr. J. W. Spencer, formerly State Geologist of Georgia, gives the following partial record of one of the city wells: ¹—

Surface clay	3.0 feet
Blue clay	70.0 "
White marl and limestone	11.0 "
Hard limestone	6.0 "
Blue clay	7.0 "
Limestone layer	0.5 "
White sand	5.0 "
Rock and clay	123.0 "

The main water-supply, which is furnished to the city, is said to be derived from the 350-foot level.

The following analysis of the water from these wells was made by Prof. H. C. White, of the University of Georgia, some years ago:—

	Grains per U. S. Gallon
Carbonate of Lime	6.322
Chloride of Sodium	1.306
Chloride of Potassium	0.114
Sulphate of Soda	0.552
Sulphate of Lime	1.015
Sulphate of Magnesia	0.125
Silica	0.104
Organic Matter and Combined Water	1.120
Total Solids Dissolved	10.658

"Sulphureted Hydrogen gas dissolved, 125 c. c. per gallon."

Field analysis of water from city well No. 1, 258 feet deep, by Mr. W. W. Burnham, of the United States Geological Survey:—

¹ First Report of Progress, Geological Survey of Georgia, p. 74, 1890.

<i>Constituents Determined</i>	<i>Parts per Million</i>
Chlorine	14.0
Total Carbonates, as Calcium Carbonate.....	127.0
Scale-forming Carbonates, as Calcium Carbonate.....	40.0
Alkali Carbonates, as Sodium Carbonate	92.2
Total Hardness, as Calcium Carbonate	—
Sulphur Trioxide (estimated)	10.0
Iron	1.0
Odor, Hydrogen Sulphide	1.0
Color	0.0
Turbidity	0.0

The Central of Georgia Railway well, which is located on lower ground than the other wells within the corporate limits, is a flowing well; but the water does not rise to a sufficient head to force it into the tank. The depth of the well is said to be 480 feet.

A field analysis of the water from the well, made by Mr. W. W. Burnham, of the United States Geological Survey, is as follows:—

<i>Constituents Determined</i>	<i>Parts per Million</i>
Chlorine	1.5
Total Carbonates, as Calcium Carbonate.....	80.2
Total Hardness, as Calcium Carbonate.....	—
Sulphur Trioxide (estimated)	5.0
Iron	0.5
Odor, Hydrogen Sulphide	4.0
Color	0.0
Turbidity	0.0

In addition to the wells, above described, there are two wells near the city limits of Americus, one of which is owned by Mr. E. C. Speer, and located one and a half miles north of Americus. This well is four inches in diameter, and 212 feet deep. The water, which is said to be apparently inexhaustible, rises to within 102 feet of the surface, and is used for drinking purposes; also, to supply a ginnery and a saw-mill. The other well, owned by Messrs. Perry & Brown, is two and a quarter miles southeast of Americus. It is 284 feet deep and four inches in diameter. The water rises to within 100 feet of the surface. Both the Speer well and the Perry & Brown well are located on elevated ground, which accounts for the low static head



RESERVOIR AND PUMPING STATION AT THE BLAKELEY DEEP WELL, BLAKELEY, EARLY COUNTY, GEORGIA.



of the water. Hard rock is reported in the Perry & Brown well at 270 feet. Above the rock, occur sands, clays and marls. The principal water-supply is said to come from a cavity two or three feet deep in the rock, at the bottom of the well. A second water-bearing stratum is reported at 100 feet; but this is cased off, and the only water used is from the first mentioned stratum. The water, which is elevated by the means of a deep-well pump, operated by a wind-mill, is used for general farm purposes. It is said to contain iron and sulphur.

HUGUENIN. — The Huguenin wells, located on the Huguenin plantation near the Flint River, in the extreme southeastern corner of Sumter county, are several in number; but only one furnishes a flow. Mr. J. M. Johnson, of Macon, Ga., the present owner of the Huguenin plantation, states, that the flowing well on his property is located at Huguenin station, one mile west of the Flint River. This well is four inches in diameter and 167 feet deep; and it flows 10 gallons a minute. Mr. Johnson reports six or seven other wells on the property, varying from 75 to 220 feet in depth; but they are all located on high ground, and are non-flowing.

ANDERSONVILLE. — The Andersonville well, which is located on Mr. A. F. Hodges' farm, near Andersonville, is three inches in diameter, and 244 feet deep. The water rises to within 132 feet of the surface. It is cased to a depth of 200 feet, and is supplied with a deep-well pump, operated by a wind-mill. The water, which is said to be quite wholesome, is used for general domestic and farm purposes. Mr. Hodges was unable to give a complete record of the well; but he states that a thick bed of kaolin was penetrated, at a depth of something like 100 feet from the surface.

OLD DANVILLE. — Mr. C. S. S. Horne's well, located near Old Danville, was completed in 1900. The well is three inches in diameter and 355 feet deep. The water, which rises to within 90 feet of the surface, is said to come from a porous rock, first struck at about 300 feet. The static head of the water is lowered by long continued pumping. The well is cased to hard rock at 114 feet. The water is used for domestic purposes.

LESLIE. — Leslie has several bored wells, varying from 100 to 125 feet in depth. These wells are all small, and are reported to have struck hard rock at 50 feet. The water rises to points varying from 14 to 40 feet from the surface, depending upon the location of the well. Long pumping is said to lower the static head of the water. The water-bearing stratum is sand, which occurs near the bottom of the well.

Besides the wells, above described, there are also deep wells at DeSoto and at Bagley station; but no report has been received from them.

The geologic horizon of the water-bearing strata of the deep wells of Sumter county varies from the Vicksburg-Jackson limestone to the Upper Cretaceous. The Windsor hotel well at Americus evidently enters the Upper Cretaceous, whereas the wells on the Huguenin plantation apparently obtain their water-supply from the Vicksburg-Jackson limestone.

TATTNALL COUNTY.

The domestic water-supply of Tattnall county is obtained principally from shallow wells. No springs of any importance are reported. Deep wells are located at Collins, Hagan, Lyons and Massas.

COLLINS. — (*Elevation, 238 feet above sea-level.*) The Collins well is eight inches in diameter and 800 feet deep. The water, which is said to rise to within 142 feet of the surface, is reported to come from a water-bearing stratum near the bottom of the well. No record has been preserved.

HAGAN. — The Hagan well, put down by the Perkins Lumber Company in 1900, is three inches in diameter and 447 feet deep. The water rises to within 60 feet of the surface. Water-bearing strata are reported at 230 and 447 feet. The following is a partial section of the well: —

Grayish sand	from	0	to	20	feet
Reddish sandstone	"	20	"	28	"
White pipe clay and sand	"	28	"	120	"
Blue marl and sand	"	120	"	230	"

LYONS. — This well, which was put down by the town authorities in 1900, at a cost of \$350, is two and a half inches in diameter and 450 feet deep. The water, which is used for general domestic purposes, rises to within 85 feet of the surface. Several water-bearing strata are reported in the well; but the present water-supply comes from 450 feet, the bottom of the well.

MANASSAS.—(*Elevation, 217 feet above sea-level.*) The Manassas well, owned by Mrs. M. F. Cummings, was completed in 1895, at a cost of \$450. It is six inches in diameter and 480 feet deep. The water rises to within 109 feet of the surface. Three or four water-bearing strata are reported, the main supply of water coming from near the bottom of the well.

The principal water-bearing strata of the Tattnall deep wells are probably the upper beds of the Vicksburg-Jackson limestone.

TAYLOR COUNTY

The only deep well in Taylor county is the Central of Georgia Railway well, located at Reynolds about four miles west of the Flint River. This well is said to have attained a depth of 700 feet. It was originally a bored well, having a diameter of eight and four inches; but, later, it was enlarged to 13 feet to a depth of 80 feet, and walled with brick. The water rises to within 75 feet of the surface. Water-bearing strata are reported at 75 and 250 feet. A partial section of the well is as follows:—

Yellow sand	from	0	to	6	feet
Variegated clay	"	6	"	31	"
Sand	"	31	"	34	"
White clay	"	34	"	37	"
Coarse gravel	"	37	"	41	"
Reddish sand	"	41	"	44	"
White clay	"	44	"	62	"
Yellow sand	"	62	"	76	"

At 600 feet, a hard, dark-colored rock is reported, which extends to the bottom of the well. This hard stratum is probably the Crystalline rock, which outcrops along the Flint River about seven miles

north of Reynolds. The water from the 75-foot water-bearing stratum is said to be quite soft. It is used by the Central of Georgia Railway for steam purposes.

Shallow wells, which vary from 20 to 100 feet in depth, are the principal source of the domestic water-supply of Taylor county.

There are many springs; but they are usually small, and their waters are only occasionally used for domestic purposes.

TELFAIR COUNTY

Telfair county has no large springs. The domestic water-supply is obtained mainly from shallow wells. The only deep wells reported are at McRae and Lumber City.

MCRÆ. — (*Elevation, 229 feet above sea-level.*) The McRae well, owned by the town, has a depth of 287 feet. It is four inches in diameter, and is said to penetrate water-bearing strata at 200 and 287 feet. The water rises to within 70 feet of the surface.

LUMBER CITY. — (*Elevation, 145 feet above sea-level.*) There are 11 deep flowing wells within the corporate limits of Lumber City. They vary from 300 to 430 feet in depth, and are from two to four inches in diameter. The first flow in these wells is obtained at 300 feet, the water rising three feet above the surface; the second flow, at 400 feet, rises 14 feet above the surface.

Mr. J. B. Spencer gives the following section of one of the deeper wells: —

Top soil	from	0	to	4	feet
Red clay	"	4	"	20	"
Coarse sand	"	20	"	30	"
Hard, blue clay, with a few layers of sandstone (Altamaha grit)	"	30	"	250	"
Quicksand	"	250	"	350	"
Limestone with water-seams from 380 to 430 feet. Limestone containing fragments of Eocene shells	"	350	"	430	"

The following analysis was made by Dr. Edgar Everhart, in the

laboratory of the Geological Survey of Georgia, from a sample of water from the public well near the station: —

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	8.28	.483
Sulphur Trioxide	25.10	1.460
Carbon Dioxide	104.80	6.111
Phosphorus Pentoxide	trace	trace
Chlorine	10.21	.595
Iron Sesqui-oxide and Alumina.....	17.19	1.003
Lime	56.12	3.273
Magnesia	8.56	.499
Potash	3.24	.188
Soda	10.89	.635
<i>Probable Combinations</i>		
Potassium Chloride	5.13	.299
Sodium Chloride	12.79	.746
Sodium Phosphate	trace	trace
Sodium Sulphate	9.43	.550
Magnesium Sulphate	25.68	1.497
Calcium Sulphate	4.54	.265
Calcium Carbonate	96.87	5.649
Iron Sesqui-oxide and Alumina.....	17.19	1.003
Total Solids	179.91	10.492
Free Carbon Dioxide	62.18	3.626

TERRELL COUNTY

The domestic water-supply of Terrell county is obtained principally from shallow wells in the Lafayette sandy clays. There are many small springs in the county; but none of large size have been reported. Successful deep wells have been put down at Dawson, Groves station and Sasser.

DAWSON.—(*Elevation, 326 feet above sea-level.*) There are 10 deep wells within the corporate limits of Dawson. These wells vary from 300 to 660 feet in depth. The water rises to within about 30 feet of the surface. There are several water-bearing strata reported

between 100 feet and the bottom of the well; but their exact depth and the static head of the water of each were not given.

Dr. J. W. Spencer, former State Geologist, gives the following record of one of the Dawson wells : —

1	Clayey white sand to	40 feet
2	Coarse sand to	80 "
3	Limestone, followed by sand and rock, repeated to....	650 "
4	Quicksand to	660 "

The Dawson wells begin in the Vicksburg-Jackson limestone, and the deeper ones seem to extend into the Cretaceous sands. The following analysis by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia, was made from water taken from the public well, located in the center of the town near the hotel : —

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	23.10	1.347
Sulphur Trioxide	19.60	1.143
Carbon Dioxide	77.20	4.501
Phosphorus Pentoxide	trace	trace
Chlorine	8.16	.475
Iron Sesqui-oxide and Alumina.....	.56	.033
Lime	60.80	3.545
Magnesia	5.61	.327
Potash	1.68	.097
Soda	10.22	.596
<i>Probable Combinations</i>		
Potassium Chloride	2.66	.155
Sodium Chloride	11.35	.665
Sodium Sulphate	9.64	.562
Sodium Phosphate	trace	trace
Magnesium Sulphate	16.83	.981
Calcium Sulphate	5.02	.290
Calcium Carbonate	104.89	6.118
Iron Sesqui-oxide and Alumina.....	.56	.033
Total Solids	174.05	10.150
Free Carbon Dioxide	31.05	1.811

GROVES STATION. — Two deep wells have been put down near Groves station, one by Mr. J. B. Groves, and the other by Mr. W. D. Davidson. The former well is three inches in diameter and 321 feet deep. Water rises to within 50 feet of the surface. Several layers of hard rock, 20 feet thick, are reported in this well, and a marl bed at 150 feet. No data have been received concerning the Davidson well.

SASSER. — There are several non-flowing deep wells in the vicinity of Sasser. They vary from 214 to 540 feet in depth, and furnish a copious supply of water, rising from 28 to 60 feet from the surface. Mr. M. N. Brewer, a well contractor, has kindly furnished the following record of Mr. J. H. Wooten's well, located two miles southwest of Sasser: —

Clay	from	0	to	50	feet
Red sand	"	50	"	80	"
Limestone	"	80	"	90	"
White sand, water-bearing	"	90	"	120	"
Limestone	"	120	"	130	"
White clay	"	130	"	140	"
Limestone with thin layers of flint.....	"	140	"	147	"
Fine white, water-bearing sand	"	147	"	160	"
Hard rock, water-bearing	"	160	"	165	"
Bluish sand	"	165	"	225	"
Limestone with thin layers of flint.....	"	225	"	260	"
Gray marl	"	260	"	300	"
Hard rock	"	300	"	303	"
White water-bearing sand	"	303	"	310	"
Limestone with layers of flint	"	310	"	340	"
Blue marl	"	340	"	428	"
Hard flint	"	428	"	431	"
Gray marl and white clay	"	431	"	504	"
Hard rock, water-bearing	"	504	"	530	"

Another well, seven miles east of Sasser, owned by Mr. J. M. King, attains a depth of only 214 feet. Water-bearing strata are reported in this well at 96, 150 and 214 feet, respectively. The water from the 214-foot stratum rises to within 28 feet of the surface.

The deep wells in the vicinity of Sasser all begin in the Vicksburg-Jackson limestone; but, as no fossils have been identified from the borings, the geological horizon of the various water-bearing strata is not known. However, the lithological character of the beds, penetrated in the Wooten well, seems to indicate that this well probably stops in the Midway-Sabine limestone, or the Upper Cretaceous.

THOMAS COUNTY

Mr. W. M. Jones, Ordinary of the county, has furnished the following list of important springs in Thomas county: the Allgood Spring, the Bold Spring, the McTyre Spring and the Miller Spring. The Allgood Spring is the only spring from which a report has been obtained. It is located in the northeastern part of Thomas county, about 20 miles from Thomasville. This spring, which is said to furnish 100 gallons a minute, is situated in a basin or depression surrounded by hillocks. The water is said to be always clear and slightly alkaline; but it forms a brownish precipitate upon standing. It issues with considerable force from a cavity in the rock, in the bottom of the basin. Small springs are quite generally met with throughout the county; but the chief source of domestic water-supply is shallow wells driven into the Lafayette sands and clays. Successful deep wells have been put down at Thomasville, Boston and Susina.

THOMASVILLE.—(*Elevation, 258 feet above sea-level.*) Thomasville has three deep wells, varying from 390 to 1900 (?) feet in depth. These wells, which supply the city-waterworks, are from eight to ten inches in diameter. The water rises to points in these wells varying from 175 to 210 feet from the surface, depending on the elevation. The only water-bearing strata reported occur at 210 and 410 feet. Dr. J. W. Spencer, formerly State Geologist of Georgia, gives the following incomplete record of one of the Thomasville wells: —¹

¹ First Report of Progress, Geological Survey of Georgia, p. 80, 1890.



ARTESIAN WELL ON THE PROPERTY OF MR. FREDERICK BAUMGARDNER, NEAR BRUNSWICK, GEORGIA, USED FOR IRRIGATING A TRUCK GARDEN.



1	Red and blue clay and sand to.....	162	feet
2	Limestone to	225	"
3	Shell-rock with water to.....	310	"
4	Rubble rock at.....	360	"
	From this level, water rises to within 210 feet of the surface.		
5	Shell-rock with copious flow at.....	410	"
6	Water at	1,400	"
7	Bottom of limestone	1,680	"
8	Quicksand, thence to	1,820	"

The Thomasville deep wells seem to begin in the Altamaha grit; but they obtain their water-supply from the Vicksburg-Jackson limestone. The quicksand below 1,680 feet is probably Cretaceous. The following analyses by Dr. Edgar Everhart were made, in the laboratory of the Geological Survey of Georgia, from samples of water taken from two city wells, which are about a quarter of a mile apart:—

WELL NO. 1

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	20.00	1.166
Sulphur Trioxide	67.60	3.942
Carbon Dioxide	129.30	7.541
Phosphorus Pentoxide	trace	trace
Chlorine	11.90	.694
Iron Sesqui-oxide .....	.20	.012
Alumina	1.40	.082
Lime	67.30	3.925
Magnesia	36.80	2.146
Soda	12.20	.711
Potash	3.10	.181
<i>Probable Combinations</i>		
Potassium Chloride	4.91	.286
Sodium Chloride	15.75	.918
Sodium Sulphate	8.82	.514
Magnesium Sulphate	87.41	5.098
Magnesium Carbonate	15.58	.909
Calcium Carbonate	120.18	7.009
Aluminum Sulphate	4.76	.278
Sodium Phosphate	trace	trace
Iron Carbonate	0.32	.019
Total Solids	277.73	16.147
Free Carbon Dioxide	68.50	3.995

WELL NO. 2

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	20.40	1.189
Sulphur Trioxide	68.40	3.989
Carbon Dioxide	135.30	7.890
Phosphorus Pentoxide	trace	trace
Chlorine	11.90	.694
Iron Sesqui-oxide	0.20	.012
Alumina	1.20	.070
Lime	67.10	3.913
Magnesia	36.40	2.123
Potash	2.50	.146
Soda	10.60	.618
<i>Probable Combinations</i>		
Potassium Chloride	4.00	.233
Sodium Chloride	16.50	.962
Sodium Sulphate	4.26	.248
Sodium Phosphate	trace	trace
Magnesium Sulphate	96.54	5.630
Magnesium Carbonate	8.86	.517
Calcium Carbonate	119.85	6.989
Aluminum Sulphate	2.84	.166
Iron Carbonate	0.32	.019
Total Solids	273.57	15.953
Free Carbon Dioxide	77.91	4.544

The following analyses, made by Dr. H. C. White, of the University of Georgia, show the sanitary condition of the Thomasville deep-well waters, which supply the city, the date of the analyses being October 8, 1900:—

<i>Sanitary Analyses</i>	Parts per One Million by Weight			
	No. 1	No. 2	No. 3	No. 4
Total Solids	285.562	286.430	285.964	286.124
Carbonate of Lime.....	160.362	161.409	160.436	160.923
Chlorine	21.551	22.060	22.404	22.138

	Parts per One Million by Weight			
	No. 1	No. 2	No. 3	No. 4
Equivalent to Sodium				
Chloride	35.559	36.399	36.967	37.528
Organic Nitrogen	0.080	0.075	0.082	0.071
Nitrogen in Ammonia....	none	none	none	none
Nitrogen in Nitrites	none	none	none	none
Nitrogen in Nitrates.....	0.850	0.900	0.873	0.905
Total Combined Nitrogen.	0.930	0.975	0.955	0.976
Required Oxygen	0.935	0.876	0.946	0.851

Points at Which Samples Were Obtained. — No. 1 Standpipe; No. 2 Main at Lee Brown's; No. 3 Cistern; No. 4 Air-lift.

Physical Examination — Appearance in Two-foot Tube. — No. 1 clear, bright, colorless; No. 2 clear, bright, colorless; No. 3 clear, bright, colorless; No. 4 clear, bright, colorless.

Odor — No. 1 None; No. 2 None; No. 3 None; No. 4 None.

Taste — No. 1 None; No. 2 None; No. 3 None; No. 4 None.

BACTERIOLOGICAL ANALYSES

"Cultivation in tubes of glucose jelly for 72 hours, after heating at 37.5° C. for 48 hours, gave no gas formation in the case of either of the samples of water.

Gelatine plate culture for 48 hours (begun immediately on receipt of the samples in sterilized bottles) gave the following numbers of colonies per cubic centimeter of water: —

Colonies per Cubic Centimeter — No. 1 315; No. 2 298; No. 3 372; No. 4 384."

BOSTON. — (*Elevation, 197 feet above sea-level.*) The Boston well, which supplies the town with water, is six inches in diameter and 290 feet deep. The water rises to within 128 feet of the surface. Water-bearing strata occur at 120, 160 and 286 feet, respectively. The well, which is supplied with a steam-pump, furnishes the town 50,000 gallons of water daily.

The following record, made out by Mr. S. S. Chandler, was obtained from Dr. T. Wayland Vaughan, of the U. S. Geological Survey:—

Yellow clay	from	0	to	90	feet
Limestone with flint	"	90	"	130	"
Hard, brown rock, water-bearing	"	130	"	220	"
Hard, brown rock	"	220	"	260	"
Soft, brown rock	"	260	"	305	"
Hard, brown rock	"	305	"	320	"

The water-bearing stratum in the Boston well is Vicksburg-Jackson limestone.

An analysis of the water by Dr. Edgar Everhart, in the laboratory of the Geological Survey of Georgia, is as follows:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	20.40	1.189
Sulphur Trioxide	7.36	.429
Carbon Dioxide	109.60	6.391
Phosphorus Pentoxide	1.12	.064
Chlorine	9.52	.555
Iron Sesqui-oxide and Alumna	18.43	1.074
Lime	56.19	3.276
Magnesia	6.64	.387
Potash	2.42	.141
Soda	7.29	.425
<i>Probable Combinations</i>		
Potassium Chloride	3.86	.225
Sodium Chloride	11.64	.679
Magnesium Chloride .....	.81	.047
Sodium Phosphate	2.24	.130
Magnesium Sulphate	11.04	.644
Magnesium Carbonate	5.50	.321
Calcium Carbonate	100.34	5.852
Iron Sesqui-oxide and Alumina	18.43	1.075
Total Solids	174.26	10.163
Free Carbon Dioxide	62.57	3.640

SUSINA. — This well, owned by Mr. S. M. Beach, is located in the southern part of the county, near the Georgia-Florida line.

It is six inches in diameter and 110 feet deep; and it furnishes a copious supply of water, rising to within 40 feet of the surface. Solid rock was struck at 85 feet. The only water-bearing stratum, reported, occurs at the bottom of the well.

TWIGGS COUNTY

Twiggs county has no deep wells, the main source of domestic water-supply being shallow wells, which vary from 20 to 90 feet in depth. These wells obtain their water from the Lafayette formation, or the underlying Claiborne, or the Cretaceous sands.

The springs of the county are usually small, furnishing ten gallons or less per minute. Such springs are often met with, near the line of contact of the siliceous Claiborne beds and the Cretaceous clays.

WARE COUNTY

WAYCROSS.—(*Elevation, 140 feet above sea-level.*) The city of Waycross has two 12-inch deep wells. The first of these was completed in 1893, and the second, which is within a few feet of the first, in 1895. Each well, with casing, cost about \$3,750.00, and will furnish, without decrease in static head, 750 gallons a minute.

Two different water-bearing strata are reported as occurring in the wells; one, in a bed of coarse sand or gravel, about 300 feet from the surface. The water from this stratum rises to within 50 feet of the surface; but the supply was thought to be insufficient for the needs of the city; consequently, the wells were continued to the second water-bearing stratum, 670 feet from the surface, from which the city water-supply is now obtained. The water from this second stratum rises to within 60 feet of the surface, which at this point has an elevation of 140 feet above sea-level.

The following is a description of the various specimens of well-borings, obtained from Mr. H. Murphy, Chairman of the Water Works Commission:—

Surface sand to	2 feet	
Motley red, yellow and white clays at	9	"
A rather coarse-grained, water-worn, reddish sand at	20	"
A specimen of sand differing mainly from the above in being of a reddish-brown color, at	30	"
Coarse quartz sand cemented by iron oxide at	40	"
Dark-gray plastic clay at	50	"
Very coarse white sand at	55	"
The same as above at	80	"
Dark gray clay at	100	"
Yellow sandy clay at	115	"
Fine gray sand containing glauconite at	130	"
Dark gray clay at	140	"
Sandy clay with glauconite at	145	"
Fine glauconitic, sandy clay at	160	"
Coarse white sand with glauconite at	185	"
Dark-gray greenish marl at	215	"
Medium fine-grained glauconitic sand at	217	"
Hard, flinty, sandy, drab-colored claystone at	226	"
Drab-colored, calcareous, sandy clay with fragments of flint and limestone at	228	"
Hard, vitreous, glauconitic sandstone at	230	"
Gray, glauconitic marl at	232	"
Fine, dark-gray sand with fragments of shell at	234	"
Blue clay at	236	"
Gray sandy marl at	275	"
Coarse sand and phosphatic pebbles; sharks' teeth, dental plates of rays, and glauconite at	300	"
Fine sand with glauconite at	302	"
Hard, compact sandstone at	310	"
Dark, sandy clay with dental plates of rays, and glauconite at	312	"
Gray marls, fragments of pectens, spines of sea-urchins etc., at	325	"
Very hard, compact sandstone at	340	"
Fine, gray glauconitic sand at	343	"
Miocene or Upper Miocene shells at	380	"
Shell marl at	400	"
Highly fossiliferous limestone, Tampa horizon at	415	"
Gray marl, pectens and spines of sea-urchins at	425	"
White, chalky, sandy limestone at	440	"
Fossiliferous limestone, having a concretionary structure at	450	"

White, chalky, arenaceous limestone at	455	feet
Gray, sandy marl at	475	"
Fine, yellow, argillaceous sand at	480	"
Gray sandstone and claystone at	500	"
White, chalky limestone at	510	"
Compact, dark-gray limestone, with fragments of corals and shells at	525	"
Shell marl at	527	"
White, chalky limestone at	530	"
Dark-gray marl, with fragments of shells at	550	"
Hard, compact, dove-colored, glauconitic claystone at	555	"
White, chalky limestone at	560	"
Gray, porous limestone, with casts of gastropods at	600	"
White, chalky limestone at	610	"
White, compact, fossiliferous limestone at	650	"
Peninsular limestone, coral, foraminifera and bryozoans in abundance at	665	"
White, chalky limestone at	670	"
White limestone made up largely of the tests of foraminif- era, some of which are an inch or more in diameter, at	675	"
White, chalky limestone at	680	"
Dark-gray fossiliferous limestone at	685	"
Fossiliferous limestone, Zeuglodon horizon, at	691	"

Following is an analysis of the water from the Waycross wells, made by Dr. H. C. White, of the University of Georgia:--

<i>Solids Dissolved</i>	<i>Grains per U. S. Gallon</i>
Carbonate of Lime	7.502
Carbonate of Iron	0.120
Sulphate of Lime	0.531
Sulphate of Magnesia	0.162
Sulphate of Potash	0.061
Sulphate of Soda	0.084
Sodium Chloride (Common Salt)	0.349
Silica	0.582
Organic Matter and Combined Water	0.965
Total	10.356

"The water is faintly turbid from suspended silica. This, however, speedily settles on standing, and becomes clear and limpid. It possesses no odor, and was found to be organically pure."

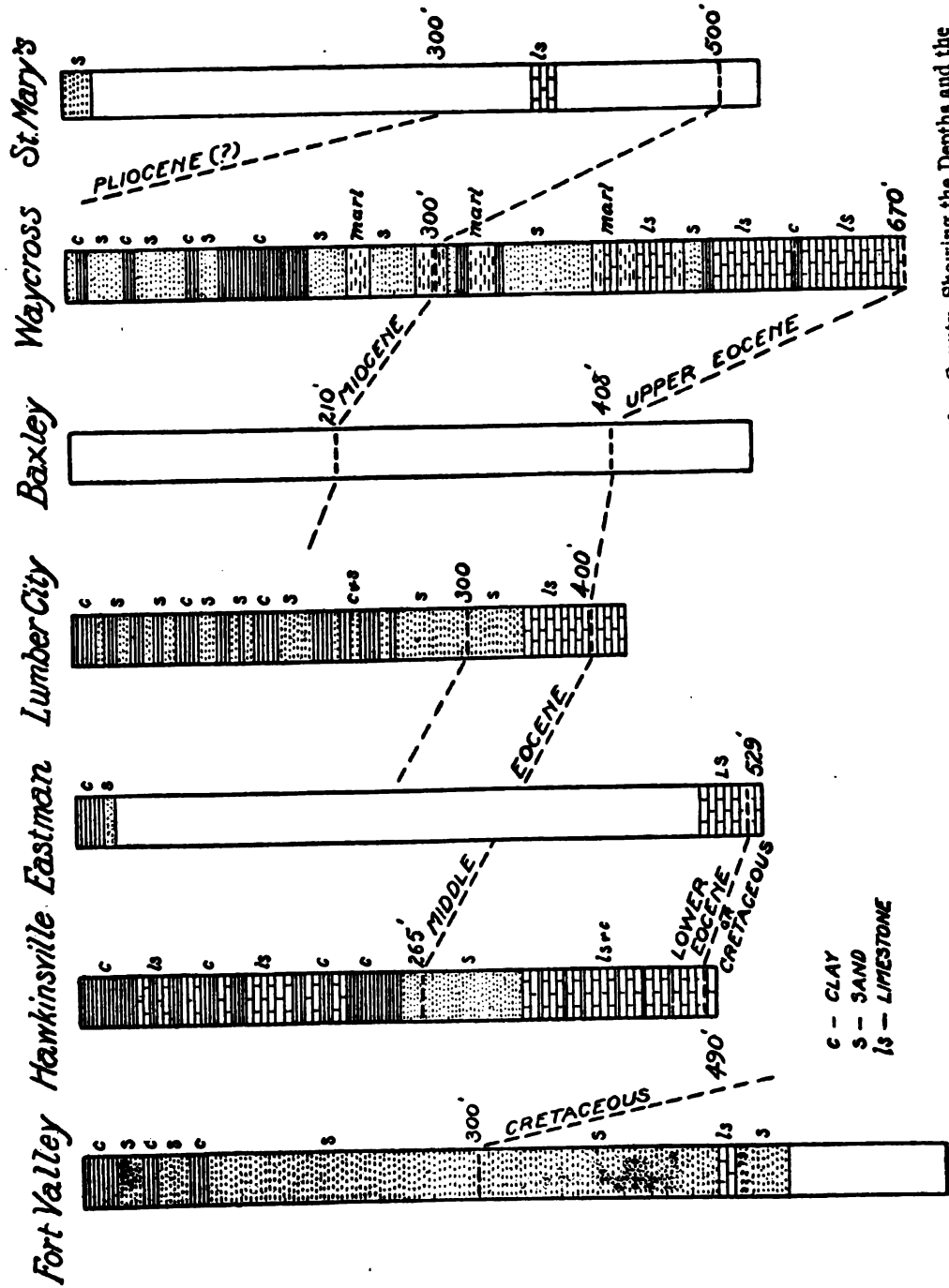


FIG. 4.—Sections of Deep Wells from Fort Valley, Houston County, to St. Mary's, Camden County, Showing the Depths and the Geological Horizons of the Main Water-bearing Strata.

Another well within the corporate limits of Waycross, owned by the Satilla Manufacturing Company, has a depth of 647 feet. It is a 6-inch well, with a capacity of 500 gallons per minute. The same water-bearing strata occur in this well as in the city wells, and the static head of the water is also practically the same.

No springs of importance are reported in Ware county.

The domestic water-supply is obtained almost entirely from shallow wells, which vary from 15 to 40 feet in depth. These wells appear to obtain their water-supply mainly from the Lafayette and Miocene sandy clays.

WASHINGTON COUNTY

Washington county has a number of springs, of considerable size. These springs are all associated with exposures of Claiborne limestone. They often make their appearance at the mouths of caverns, or in the region of limesinks. Such springs occur near the corporate limits of Sandersville and Tennille, and also near Sunhill. These springs, before they emerge on the surface, form, in places, underground streams, which can be traced by a chain of limesinks. The shallow wells of the county usually vary from 30 to 80 feet. They obtain their water-supply from the Lafayette sands, or the underlying Claiborne beds. The water from these wells is usually soft, and well suited to both domestic and technical purposes. This class of wells is often more or less affected by long droughts; but they usually furnish ample water for farm purposes, the object for which they are generally put down. The only deep wells in the county are located at Sandersville, Tennille and Davisboro.

SANDERSVILLE. — There are four deep wells within the corporate limits of Sandersville, two of which are owned by the city, and two by individuals. The first city well was put down in 1900, at a cost of \$800.00. This well, which is 4½ inches in diameter, has a depth of 431 feet. Water-bearing sands are reported at 70, 120, 185, 325 and 425 feet, respectively. The static head of the lower water-bearing stratum is said to be 134 feet below the surface. The water of the first and second strata is reported to rise a short distance above

the point, where they were first struck; but, as the well was increased in depth, it subsided to 134 feet. This decrease in the static head of the two upper water-bearing strata is evidently due to the waters in the lower strata having a natural outlet at a lower level than the upper strata. The capacity of these various water-bearing strata is estimated at from 20 to 120 gallons per minute, the lowest furnishing the maximum amount.

The second city well, which is within 200 feet of the first, was completed in 1904. This well attains a depth of only 195 feet. It is six inches in diameter, and is reported to furnish 150 gallons per minute. The following record was made from samples of the borings from the first city deep well, kindly furnished by Mr. C. E. Warthen:—

White and dark clays with pyrite.....	at 35 feet
White, sandy limestone	" 85 "
Gray limestone, with fragments of shells.....	" 103 "
Dark clay	" 160 "
Yellow, coarse sand	" 215 "
White kaolin	" 270 "
Fine, white sand	" 285 "
Dark, pyritiferous sand	" 335 "
White kaolin	" 370 "
Rather coarse, brownish sand.....	" 387 "
White sand	" 426 "
Fine, white sand	" 436 "

The character of the water from this well is shown by the following analysis, made by Dr. Edgar Everhart, in the laboratory of the Geological Survey of Georgia:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	27.12	1.581
Sulphur Trioxide	3.47	.202
Carbon Dioxide	139.00	8.106
Phosphorus Pentoxide	trace	trace
Chlorine	6.80	.396
Iron Sesqui-oxide and Alumina.....	10.25	.597
Lime	105.40	6.147
Magnesia	4.50	.262
Potash	2.29	.133
Soda	13.34	.777

<i>Probable Combinations</i>	Parts per Million	Grains per U. S. Gallon
Potassium Chloride	3.63	.216
Sodium Chloride	8.35	.487
Sodium Sulphate	5.98	.349
Sodium Phosphate	trace	trace
Sodium Carbonate	10.79	.629
Magnesium Carbonate	9.45	.551
Calcium Carbonate	188.22	10.976
Iron Sesqui-oxide and Alumina.....	10.25	.598
Total Solids	263.79	15.384
Free Carbon Dioxide.....	46.77	2.728

The two private deep wells of Sandersville, one owned by Mr. Lewis Cohen, and the other, by Dr. C. G. Rawlins, each has about the same depth as the deeper city well, and penetrates similar strata.

TENNILLE.—(*Elevation, 477 feet above sea-level.*) Tennille has two deep wells, one put down in 1892, and the other in 1904. The first well, which was unsuccessful, is said to have attained a depth of 990 feet. It begins as a 12-inch well, but it was finally decreased to 4 inches. The two principal water-bearing strata, reported, occur at 380 and 426 feet. Water from the first stratum is said to rise to within 90 feet of the surface, which is greater by about 100 feet than the static head of the second stratum.

The following is a record of this deep well, copied from the notes of the well contractor:—

Sandy clay	from	0	to	38	feet
White clay	"	38	"	52	"
Yellow, sandy clay	"	52	"	80	"
White sand	"	80	"	91	"
Yellowish limestone, in the form of boulders.	"	91	"	96	"
Gray sand	"	96	"	103	"
White sand	"	103	"	130	"
White sandstone containing shells.....	"	130	"	140	"
Bluish marl	"	140	"	185	"
Yellow clay	"	185	"	194	"
Brownish colored sand, containing sharks' teeth and fragments of oyster shells.....	"	194	"	210	"
Blue marl	"	210	"	260	"

Quicksand	from 260 to 270 feet
Blue marl	" 270 " 300 "
White clay	" 300 " 310 "
Blue clay	" 310 " 350 "
Blue and gray sands.....	" 350 " 360 "
Blue clay	" 360 " 404 "
Quicksand	" 404 " 436 "
White clay and sand.....	" 436 " 440 "
Coarse, white sand	" 440 " 470 "
White, "sticky" clay.....	" 470 " 500 "
Red clay	" 500 " 530 "
White clay	" 530 " 550 "
Clay and sand, except at 820 feet, where sand- stone occurs	" 550 " 990 "

The following field-analysis of the water from the Tennille deep well, made by Mr. W. W. Burnham, has been furnished by Mr. M. O. Leighton, Chief of the Division of Hydro-Economics, United States Geological Survey:—

<i>Constituents Determined</i>	<i>Parts per Million</i>
Chlorine	4.0
Total Carbonates, as Calcium Carbonate.....	115.0
Carbonates (scale-forming), as Calcium Carbonate.....	—
Alkaline Carbonates, as Sodium Carbonate.....	—
Sulphur Trioxide	trace
Total Hardness	166.0
Iron	0.0
Odor, Hydrogen Sulphide.....	1.0
Color	0.0
Turbidity	0.0

DAVISBORO. — The Davisboro deep well, put down by the town authorities in 1888, has a depth of 325 feet. It is a 2-inch well, flowing five gallons per minute, the water rising three feet above the surface. The water-bearing strata are reported at 88 and 100 feet, respectively, the latter, only, flowing.

Mr. T. L. Brown, of Davisboro, has furnished the following record of the Davisboro well:—

Sand	from	0	to	20	feet
Brownish clay with white pebbles.....	"	20	"	40	"
Coarse, white sand	"	40	"	60	"
Dark, greenish marl.....	"	60	"	80	"
Shell-rock, with sharks' teeth.....	"	80	"	88	"
Water-bearing sands, with fragments of shells, which continue to quicksand at the bottom of the well	"	88	"	100	"

The following analysis of the water from the Davisboro well was made by Dr. Edgar Everhart, in the laboratory of the Geological Survey of Georgia:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	12.72	.742
Sulphur Trioxide	5.95	.347
Carbon Dioxide	118.48	6.910
Phosphorus Pentoxide	trace	trace
Chlorine	5.60	.327
Iron Sesqui-oxide and Alumina.....	4.02	.234
Lime	82.57	4.815
Magnesia	3.05	.178
Potash	4.47	.261
Soda	18.92	1.103
<i>Probable Combinations</i>		
Potassium Chloride	7.08	.413
Sodium Chloride	3.62	.212
Sodium Sulphate	10.56	.616
Sodium Carbonate	21.15	1.233
Sodium Phosphate	trace	trace
Magnesium Carbonate	6.40	.373
Calcium Carbonate	147.45	8.599
Iron Sesqui-oxide and Alumina.....	4.02	.234
Total Solids	213.00	12.422
Free Carbon Dioxide	41.47	2.418

All the deep wells in Washington county commence in the Claiborne and probably stop in the Lower Cretaceous. The main water-supply in most of these wells probably comes from the lower Claiborne beds.

WAYNE COUNTY

Shallow wells, varying from 15 to 60 feet in depth, are the chief source of domestic water-supply in Wayne county. No springs of any importance are reported. The only deep wells from which data have been received, are at Jesup and near Doctortown. This well, put down by the town council in 1890, at a cost of \$500.00, is said to be 500 feet deep. Water-bearing strata are reported at 287 and 500 feet.

Dr. J. W. Spencer, formerly State Geologist, gives the following record:—¹

1	Sand to	10	feet
2	Quicksand to	14	"
3	Yellow clay soil, with layers of quicksand to.....	26	"
4	Quicksand to	52	"
5	Limestone to	55	"
6	Quicksand to	65	"
7	Limestone to	78	"
8	Clay with sand to	233	"
9	Soft spongy rock to	237	"
10	Blue marl to	490	"
11	Water-bearing quicksand. Water rose to within 33 feet of the surface.		

This well begins apparently in the Altamaha grit and extends probably into the Eocene.

DOCTORRTOWN. — The following log of a prospecting oil well, located about one mile southwest of Doctortown, Wayne county, was furnished by Mr. C. A. Gilson, well contractor:—

Sand	from	0	to	20	feet
Sand and yellow clay with some shells...	"	20	"	55	"
Sand and laminated clay.....	"	55	"	80	"
Conglomerate and marl. Water rises to within 20 feet of the surface.....	"	80	"	95	"
Sand, gravel and laminated clay.....	"	95	"	135	"
Greenish-gray marl and chalky limestone with some pebbles	"	135	"	185	"

¹ Geological Survey of Georgia; First Report of Progress, 1890-'91, p. 75.

Quicksand and marl	from	185	to	230	feet
Layers of hard rock, marl and conglomerate	"	230	"	255	"
Marl with sandstone layers and some limestone	"	255	"	295	"
Quicksand with layers of conglomerate . .	"	295	"	325	"
Soft limestone and sandstone with flint layers 2 feet thick	"	325	"	353	"
Quicksand	"	353	"	393	"
Marl and soft limestone	"	393	"	408	"
Quicksand containing a large supply of water	"	408	"	415	"
Quicksand	"	415	"	465	"
Soft limestone	"	465	"	467	"
Hard limestone with layers of sand	"	467	"	511	"
Water-bearing limestone (quicksand at 793 feet)	"	511	"	829	"
Gray limestone and brown sandstone . . .	"	829	"	849	"
Sandstone	"	849	"	894	"
Limestone	"	894	"	929	"
Soft limestone	"	929	"	939	"
Salt water and sand	"	939	"	955½	"
Hard limestone	"	955½	"	966	"
Limestone in soft and hard layers	"	966	"	988	"
Limestone with some sand	"	988	"	1,005	"
Limestone	"	1,005	"	1,019	"
Limestone with two shell layers	"	1,019	"	1,036	"
Limestone with hard layers	"	1,036	"	1,051	"
Limestone, very hard	"	1,051	"	1,064	"
Limestone and sand	"	1,064	"	1,070	"
Limestone, mostly hard	"	1,070	"	1,204	"
Limestone	"	1,204	"	1,222	"
Hard limestone	"	1,222	"	1,255	"
Soft limestone	"	1,255	"	1,314	"
Hard limestone	"	1,314	"	1,332	"
Soft limestone	"	1,332	"	1,470	"
Gray and brown sands	"	1,470	"	1,640	"
Dark brown sand	"	1,640	"	1,724	"
Sand mixed with pebbles	"	1,724	"	1,750	"
Light-colored sand	"	1,750	"	1,762	"
Glauconitic sand	"	1,762	"	1,901	"

This well was commenced in July, 1905, and completed the last

of May, 1906, at a cost of between \$15,000 and \$20,000. It is cased with 10-inch pipe to 460 feet, 8½-inch pipe to 540 feet and 6-inch pipe to a point within a few feet of the bottom. The first hard ledge of rock reported in the well occurs at 480 feet. The sample of borings, marked 550 to 725 feet, contains numerous fragments of Eocene shells. The material consists largely of limestone, and it continues to 1,490 feet, below which point the following samples were collected:—

Sample, marked 1,470 feet, consists of medium fine-grained sand with fragments of corals, shells and particles of glauconite.

Sample, marked 1,505 feet, glauconitic sand with sharks' teeth and fragments of shells.

Sample, marked 1,750 feet, grayish marl made up largely of fragments of corals and shells.

Sample, marked 1,838 feet, glauconite.

From a study of the log and specimens of the well, I am of the opinion that of the formations, through which the well is sunk, are as follows: between 80 feet and approximately 500 feet are Miocene, and below this, extending to about 1,700 feet, Eocene. The well stops probably in the Upper Cretaceous.

WEBSTER COUNTY

Webster county has numerous springs, some of which are of large size. One of these springs is to be seen on Mr. G. W. Cole's farm, about two miles south of Preston. This spring, which furnishes 20 gallons or more of water per minute, is located at the base of a bluff of Midway limestone, at the margin of the Kinchafoonee Creek swamp.

Other springs, similar to the Cole Spring, are reported in the county; but none of them were visited by the writer.

The domestic water-supply of the county is obtained almost entirely from shallow wells. As far as is known, no attempt has been made in Webster county to secure water by deep boring.



ARTESIAN WELL AT THE RESIDENCE OF MR. H. W. LLOYD, NEAR BRUNSWICK, GEORGIA, USED TO IRRIGATE A
TRUCK GARDEN.



WILCOX COUNTY

There are no springs of any importance, reported, in Wilcox county. The main source of domestic water-supply is shallow wells.

Successful deep wells have been put down only at Abbeville, Rochelle and Pineview.

ABBEVILLE. — There are two deep wells at Abbeville, one owned by the town and the other, by the Abbeville Cotton Seed Oil Company. The former well, which was completed in 1898 at a cost of \$1,600, is 585 feet deep. It varies from two to eight inches in diameter, and it furnishes 50 gallons of water per minute. The water rises to within 60 feet of the surface. Several water-bearing strata are reported between 100 feet and the bottom of the well. Cavernous limestone is said to be the main water-carrier. The well is supplied with a pump which furnishes the town with water.

The Abbeville Cotton Seed Mill well was put down in 1902 at a cost of \$350.00. It is a 3-inch well, 175 feet deep; and it furnishes daily 13,000 gallons of water, used chiefly for boiler purposes. The water rises to within 80 feet of the surface. Water-bearing strata are reported at 105 feet and 175 feet, respectively.

The following well record was furnished by the company: —

Sand and clay	from	0	to	20	feet
Sand	"	20	"	60	"
Hard, flinty rock	"	60	"	175	"

ROCHELLE. — The Rochelle well, which is owned by the town, is three inches in diameter and 286 feet deep. The only water-bearing stratum is near the bottom of the well. It furnishes a good supply of water, rising to within 150 feet of the surface. The water is used for general domestic purposes. The following record has been furnished by Mr. J. C. Conn, of Atlanta: —

Red clay	from	0	to	75	feet
Black sand	"	75	"	150	"
Hard, flinty rock	"	150	"	286	"

This well, together with the Abbeville well, seems to obtain its water-supply from the Vicksburg-Jackson limestone.

PINEVIEW. — There are three deep wells at Pineview, each of which has about the same depth and penetrates similar strata. The water in all these wells rises to within 60 feet of the surface. The only water-bearing stratum reported is near the bottom of the wells.

The following record of Mr. J. S. Bruce's well has been kindly furnished by the owner: —

Reddish clays	from	0 to	20 ft.
Yellowish jointed clays	"	20 "	120 "
Soft limestone	"	120 "	275 "
Water-bearing cavity	"	275 "	293 "

WILKINSON COUNTY

Deep wells are reported in Wilkinson county at Irwinville, Toombsboro and Gordon. Two attempts have been made at Irwinville to obtain artesian water. The first of these wells, located on low ground, was put down to a depth of 300 feet, at which point a water-bearing stratum, yielding a small flow, was struck. This well continued to flow for a time; but it finally became filled with sand, and it was abandoned. The water is said to have had a rather offensive odor and an unpleasant taste, due, probably, to the presence of hydrogen sulphide and iron oxide.

Another well, located on high ground, was extended to the depth of 600 feet; but the water did not rise higher than to within 50 feet of the surface.

TOOMBSBORO. — (*Elevation, 237 feet above sea-level.*) The Toombsboro well was put down in 1882, at a cost of \$320. It is one and a quarter inches in diameter and 320 feet deep; and it furnishes a flow rising three feet above the surface. When the well was first completed, it flowed eight gallons per minute; but the flow gradually decreased, until it finally ceased about four years after the well was completed. During last spring, a second deep well was put down at Toombsboro; but no record of this well was secured.

GORDON.—(*Elevation, 354 feet above sea-level.*) A 2-inch well, 365 feet deep, with water rising to within 19 feet of the surface, is reported at Gordon. About 20 feet of soft limestone, together with sands and clays, are said to have been penetrated in this well. The only water-bearing stratum, reported, is near the bottom of the well.

All the deep wells of Wilkinson county obtain their water-supply from the Cretaceous sands. No springs of importance are reported. Shallow wells, the chief source of domestic water-supply, are to be had at almost any point in the county, at depths varying from 20 to 80 feet.

WORTH COUNTY

Hon. J. W. Price, the Ordinary of Worth county, reports the following large springs in the county:—

Mr. G. G. Ford's spring, nine miles north of Isabella.

Mr. E. D. Whidden's spring, seven miles north of Isabella.

Mr. N. W. Ford's springs (three in number), eleven miles northwest of Isabella.

Mr. N. F. Mercer's springs (several), fifteen miles northwest of Isabella.

These springs are said to be all large, and they are all tributaries to the Flint River.

Shallow wells, varying from 20 to 70 feet in depth, are the main source of domestic water-supply. Successful deep wells have been put down at Doles, Poulan, Warwick and Worth.

DOLES.—The well at Doles, owned by Mr. J. M. Chapman, is three inches in diameter and 257 feet deep; and it furnishes a copious supply of water rising to within 12 feet of the surface.

The following record of this well was furnished by the well-contractor:—

1	Clay to	15	feet
2	Blue marl to	96	"
3	Limestone to	108	"
4	Coarse pebbles to	123	"
5	Limestone with shells to.....	143	"

6	Blue marl or clay to.....	193 feet
7	Limestone, containing corals and shells to.....	209 "
8	Flint	(?)

POULAN. — (*Elevation, 312 feet above sea-level.*) The first attempt to secure water at Poulan, by deep borings, was made by Mr. J. C. McPhaul in 1890. Mr. McPhaul made two or three efforts to obtain a flowing well at Poulan, but each time he was unsuccessful. At the time of the writer's visit in 1897, Mr. McPhaul furnished the following notes on his well, then in use. The well is from six to eight inches in diameter, and 315 feet deep. Water rises to within 75 feet of the surface. The main water-bearing stratum occurs somewhere between 130 and 170 feet. Another water-bearing stratum is reported as occurring at a point between 85 and 95 feet from the surface, but it is cased off. The static head of the water in the well is said to be lowered as much as 75 feet during a long continued drought. The water is used chiefly for steam purposes, 75,000 gallons being used daily.

Mr. McPhaul has furnished the following record:—

1	Red clay to	15 feet
2	Yellow clay to	20 "
3	White clay to	35 "
4	Hard rock at	75 "

The last extends to the bottom of the well.

The following report on the Poulan Cotton Mill deep well by Mr. W. W. Burnham, has been furnished by Mr. M. O. Leighton, Chief of the Division of Hydro-Economics, United States Geological Survey:—

The well was completed in June, 1903, at a cost of \$250.00. It is four and a half inches in diameter, and 198 feet deep; and it has a maximum capacity of 42 gallons per minute. The water, which is used to supply the cotton-mill, rises to within 90 feet of the surface, or about 10 feet above the railroad at the station. The well is supplied with an air-lift pump valued at \$300.00. The cost of raising

the water is reported by the treasurer of the company to be from 15 to 20 cents per 1,000 gallons.

The character of the water is shown by the following field-analysis by Mr. Burnham:—

<i>Constituents Determined</i>	<i>Parts per Million</i>
Chlorine	4.0
Total Carbonates, as Calcium Carbonate.....	169.0
Scale-forming Carbonates, as Calcium Carbonate.....	33.0
Alkali Carbonates, as Sodium Carbonate	144.0
Total Hardness, as Calcium Carbonate	207.0
Sulphur Trioxide (estimated)	5.0
Iron	trace
Odor, as Hydrogen Sulphide	2.0
Color	0.0
Turbidity	0.0

Another deep well at Poulan, on which Mr. Burnham has furnished data, is the Jordan & Simerly well, located at a saw-mill half-a-mile west of the post-office. This well, completed in June, 1904, at a cost of \$330, is six inches in diameter, and 220 feet deep. Water-bearing strata are reported at 90 and 210 feet, respectively. Water rises to within 82 feet of the surface, or from 5 to 10 feet above the railroad track at the station. Sand and clay are reported in the well to 120 feet, limestone at 145 feet, and quicksand at 220 feet. The water is used only for boiler purposes.

WARWICK. — Mr. C. P. Romes' well at Warwick is two and eight inches in diameter and 497 feet deep; and it furnishes a large supply of sulphureted water. Twenty-two feet from the surface, the drill is said to have struck a stream of water eight feet in depth. The formation encountered in the well is reported to consist principally of limestone.

WORTH. — The Enterprise Lumber Company's well, put down in 1896, has a depth of 300 feet. The water is used for boiler purposes; it rises to within 60 feet of the surface. Red clay is reported in the well to 30 feet, below which occur sand, clay and limestone.

The deep wells of Worth county all obtain their water-supply from the Vicksburg-Jackson limestone, except the wells at Worth, which probably obtain their supply from the Lower Miocene.

CHAPTER X

DETAILED NOTES ON THE UNDERGROUND WATERS OF THE CRYSTALLINE AREA

The underground waters of the Crystalline area, which includes both the Piedmont Plateau and the Appalachian physiographic divisions of the State, may be considered, for convenience of description, under the following heads: Deep Wells, Shallow Wells and Springs.

DEEP WELLS

By the term deep wells, as above used, is meant drilled or bored wells, which attain a depth of 100 feet or more. Wells, having a depth of less than 100 feet will be discussed under the heading of shallow wells.

FULTON COUNTY

THE ATLANTA DEEP WELLS. — The deep wells of the Crystalline area are limited in number. One of the most noted of these wells is the so-called artesian well of Atlanta, which was constructed by the city in 1885. This well, which has a depth of 2,175 feet, penetrates gneissoid and schistose rocks. The capacity of the well is reported to have been only about 2,000 gallons per hour. The water-supply is said to have come from several small fissures or cracks, struck by the drill at various points between 100 and 1,200 feet from the surface. Below 1,160 feet, no water-bearing fissures were reported. A chemical analysis of the water from this well, when it was first completed, showed the water to be a normal freestone water, containing less than 12 grains of mineral matter per gallon, with practically no surface contamination. Later, there was a rather remarkable increase in the amount of mineral matter present, mainly sodium chloride, as may be seen by the following table of analyses taken from the annual report of the City Water-works Board for 1889: —

Sample No.	Date	Grains per U. S. Gallon		Parts per 1,000,000		REMARKS
		Total Solids	Sodium Chloride	Free Ammonia	Albuminoid Ammonia	
10	1885	.....	2.97	0.02	0.06	Analyzed by J. M. McCandless
9	1886	10.7	2.00	0.01	0.01	" " "
11	Oct. 1886	21.00	8.35	0.01	0.04	" " "
39	Nov. 1888	22.35	10.56	0.02	0.01	" " "
40	Nov. 1888	18.30	11.36	0.04	0.08	" " H. C. White
41	Nov. 1888	23.50	11.79	0.02	0.06	" " W. J. Gascoyne

Owing to the rapid increase in the amount of sodium chloride present in the water, which was supposed to be due to surface contamination, the well was finally abandoned, after a continuous use of about ten years.

In addition to the deep well here described, there are three other deep wells within the corporate limits of Atlanta, all owned by the Georgia Railway & Electric Company. One of these, formerly owned by the late Atlanta Gas-light Company, and located on Foundry street, near the Western & Atlantic Railroad, was completed in 1895. It is eight inches in diameter and 278 feet deep; and it furnishes daily for 18 hours, the length of time the pump is operated, 150 gallons per minute. The water is soft, and is said to be well suited for boiler purposes. It rises to within 80 feet of the surface, and comes apparently from fissures and seams in the gneisses and schists. An analysis of the water from this well, made by Dr. Edgar Everhart, in the laboratory of the Geological Survey of Georgia, is as follows:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	38.60	2.251
Sulphur Trioxide	28.80	1.679
Carbon Dioxide	82.82	4.830
Phosphorus Pentoxide	trace	trace
Chlorine	35.85	2.091
Iron Sesqui-oxide and Alumina	2.50	.146
Lime	73.30	4.274
Magnesia	16.19	.944
Potash	6.43	.375
Soda	30.74	1.793

200 UNDERGROUND WATERS OF THE CRYSTALLINE AREA

<i>Probable Combinations</i>	Parts per Million	Grains per U. S. Gallon
Potassium Chloride	10.40	.606
Sodium Chloride	50.90	2.968
Sodium Sulphate	8.63	.503
Magnesium Sulphate	35.91	2.094
Magnesium Carbonate	8.86	.517
Calcium Carbonate	130.99	7.639
Iron Sesqui-oxide and Alumina	2.50	.146
Total Solids	286.79	16.724
Free Carbon Dioxide.....	10.49	.612
<i>Sanitary Analysis</i>		
Nitrogen in Free Ammonia.....	0.010	
Nitrogen in Albuminoid Ammonia.....	0.153	
Nitrogen in Nitrites.....	trace	
Nitrogen in Nitrates.....	0.100	
Chlorine	35.850	

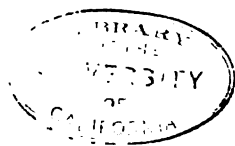
This water is regarded as unsafe for drinking purposes, on account of its high albuminoid ammonia and chlorine.

The other two wells of the Georgia Railway and Electric Company are located at their power-house on Davis street, near Jones Avenue. One of the wells was completed in 1899, and the other, in 1900. The former well is 14 inches in diameter, and 350 feet deep. The water rises to within 12 feet of the surface. By continuous pumping, the water-supply is said to be 52 gallons per minute. The other well, owned by the Georgia Electric Railway Company, is also 14 inches in diameter; but it has a depth of 638 feet. The water-supply from this well is only 56 gallons per minute, or four gallons more than the shallower well. The wells are located about 80 feet apart, and are used chiefly to supply water for cooling condensers. The water in each well rises to within 12 feet of the surface.

An analysis of the water from the 350-foot well of the Georgia Railway & Electric Company, by Dr. Edgar Everhart, Chemist of Geological Survey of Georgia, is as follows:—



A FLOWING ARTESIAN WELL AT WADLEY, JEFFERSON COUNTY, GEORGIA.



UNDERGROUND WATERS OF THE CRYSTALLINE AREA 201

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	26.50	1.545
Sulphur Trioxide	18.10	1.055
Carbon Dioxide	93.34	5.443
Phosphorus Pentoxide	trace	trace
Chlorine	6.50	.379
Iron Sesqui-oxide and Alumina	1.40	.082
Lime	62.80	3.662
Magnesia	4.07	.237
Potash	6.93	.404
Soda	29.68	1.731
<i>Probable Combinations</i>		
Potassium Chloride	11.00	0.641
Sodium Chloride	2.10	.122
Sodium Sulphate	32.13	1.874
Sodium Carbonate	24.86	1.450
Magnesium Carbonate	8.55	.498
Calcium Carbonate	112.14	6.540
Iron Sesqui-oxide and Alumina	1.40	.082
Total Solids.....	218.68	12.752
Free Carbon Dioxide	29.20	1.703
<i>Sanitary Analysis</i>		
Nitrogen in Free Ammonia.....	0.140	
Nitrogen in Albuminoid Ammonia.....	0.070	
Nitrogen in Nitrites.....	0.067	
Nitrogen in Nitrates	0.060	
Chlorine	6.500	

This water is considered unsafe for drinking purposes, on account of its high free ammonia and nitrites.

FORT MCPHERSON DEEP WELLS. — There are three deep wells at Fort McPherson, near Atlanta, two of which are 10-inch wells, and the other, 8-inch. The 10-inch wells are each 500 feet deep. One of these wells was completed in 1885, and the other in 1904, at a cost of \$10.00 per foot. The first furnishes 3,200 gallons per hour, and the second, only 875 gallons. The 8-inch well was put down in 1882 at a cost of \$7.50 per foot. This well is 250 feet deep, and

furnishes 1,600 gallons per hour. All these wells are located within a radius of 100 feet. They have the same static head (50 feet below the surface), and are alike affected by droughts.

The following notes on the 10-inch well, completed in 1904, were furnished by Mr. Perry Andrews, the contractor:—

Clay and sand	from 0 to 50 feet
Hard rock (gneiss) at	70 "
Water-bearing fissure at	112 "
Very hard rock; continues to 280 feet at	130 "
Water-bearing fissure at	328 "
Water apparently increased at	350 "
Test showed water 720 gallons per hour at	375 "
Test showed no increase of water at	425 "
Test for 24 hours, no increase at	472 "
Test for 24 hours; no increase at	505 "

Well cased to 86 feet in hard rock.

An analysis of the water from this well, made July 13th, 1904, by Mr. Edwin Hodge, Chemist-in-charge, Surgeon General's Office, U. S. War Department, Washington, D. C., shows the following results:—

<i>Sanitary Analysis</i>	Parts per Million
Chlorine	3.5000
Nitrogen as Nitrites	none
Nitrogen as Nitrates	0.0375
Free Saline Ammonia	0.0320
Albuminoid Ammonia	0.0180
Oxygen Used	0.2619
Total Solids	59.5000
Loss on Ignition	17.0000

The water is clear, colorless, odorless and devoid of sediment.

An analysis of water from the same well, made December 31, 1904, by Dr. Edgar Everhart, in the laboratory of the Geological Survey of Georgia, is as follows:—

UNDERGROUND WATERS OF THE CRYSTALLINE AREA 203

<i>Sanitary Analysis</i>	Parts per Million
Nitrogen in Free Ammonia	0.010
Nitrogen in Albuminoid Ammonia	0.073
Nitrogen in Nitrites.....	none
Nitrogen in Nitrates	trace
Chlorine	1.780
Volatile and Organic Matter	17.000
Mineral Matter	47.000
Total Solids	64.000

An analysis of the water from the 8-inch well made by Dr. Edgar Everhart, December 31, 1904, in the laboratory of the Geological Survey of Georgia, follows:—

<i>Sanitary Analysis</i>	Parts per Million
Nitrogen in Free Ammonia	0.04
Nitrogen in Albuminoid Ammonia	0.06
Nitrogen in Nitrites.....	none
Nitrogen in Nitrates	trace
Chlorine	1.78
Volatile and Organic Matter	7.00
Mineral Matter	54.00
Total Solids	61.00

A fourth deep well is now being put down on the Government reservation at Fort McPherson. It is located some distance from the other wells; but it will penetrate practically the same rocks.

COBB COUNTY

All the deep wells, so far reported in Cobb county, are located in or near the town of Austell, on the Southern Railway, about 18 miles northwest of Atlanta. One of the first of these wells put down was the so-called "Sulpho-Magnesia Artesian" well, located near Sweetwater Creek, three-quarters of a mile northwest of Austell. This well, together with the "Artesian Lithia" well, located a few hundred yards further up the creek, was put down with the hope of discovering a seam of anthracite coal, which was supposed to exist in that vicinity.

THE AUSTELL DEEP WELLS.—The "Sulpho-Magnesia Artesian" well is reported to be 750 feet deep. It is two inches in diameter, and penetrates gneissoid rocks for its entire depth. The water rises to within a few inches of the surface, and is used to a considerable extent in manufacturing ginger ale. It is also sold in Atlanta and elsewhere as a mineral water. The chemical composition of the water is shown by the following analysis made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	18.00	1.050
Sulphur Trioxide	3.00	.175
Carbon Dioxide	120.50	7.027
Phosphorus Pentoxide .....	.35	.020
Arsenic	trace	trace
Chlorine	7.70	.449
Bromine	trace	trace
Iron Sesqui-oxide .....	.87	.051
Alumina	1.25	.073
Manganese	trace	trace
Lime	35.00	2.041
Magnesia	6.00	.350
Potash	5.10	.297
Soda	15.00	.875
Lithia	2.50	.146
<i>Probable Combinations</i>		
Lithium Chloride	7.20	.420
Potassium Chloride	3.74	.218
Potassium Bromide	trace	trace
Potassium Sulphate	5.07	.296
Sodium Sulphate	1.19	.069
Sodium Phosphate .....	.66	.039
Sodium Arsenite	trace	trace
Sodium Carbonate	24.75	1.443
Magnesium Carbonate	12.60	.735
Calcium Carbonate	62.50	2.645
Aluminum Sulphate	5.45	.318
Iron Carbonate	2.61	.153
Total Solids	131.35	7.660
Free Carbon Dioxide	82.73	4.825

After this well is pumped continuously for some time, the water has a distinct odor of hydrogen sulphide. The supply, secured by using a hand pump, is said to be 1,000 gallons per hour. The water is reported to come from several fissures in the rock at various depths.

The "Artesian-Lithia" well differs from the "Sulpho-Magnesia Lithia" well, mainly in the chemical composition of its water. Both wells have the same diameter, and apparently penetrate the same rocks. It is claimed by some, that this well attains a depth of more than 900 feet; while others state, that it is not so deep as the "Sulpho-Magnesia" well.

The mineral constituents of the water from the "Artesian Lithia" well, as determined by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia, are as follows:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	24.30	1.417
Sulphur Trioxide	148.40	8.654
Carbon Dioxide	163.30	9.523
Phosphorus Pentoxide .....	.40	.023
Arsenic	trace	trace
Chlorine	1,032.00	60.184
Bromine	14.00	.816
Iron Sesqui-oxide .....	.30	.017
Alumina .....	.90	.052
Lime	169.10	9.862
Magnesia	21.40	1.258
Potash	6.40	.373
Soda	876.80	51.133
Lithia	17.00	.991
<i>Probable Combinations</i>		
Lithium Chloride	47.00	2.741
Potassium Bromide	16.20	.945
Sodium Chloride	1,634.30	95.309
Sodium Bromide	4.00	.233
Sodium Sulphate	21.10	1.231
Sodium Phosphate .....	.80	.047
Magnesium Sulphate	64.20	3.744

	Parts per Million	Grains per U. S. Gallon
Calcium Sulphate	153.20	8.934
Calcium Carbonate	189.30	11.040
Aluminum Sulphate	3.90	.228
Iron Carbonate .....	.90	.052
Total Solids	2,159.20	125.920
Free Carbon Dioxide.....	80.00	4.665

The water from this well has a somewhat extensive sale as a mineral water. The supply, which is several gallons per minute, is said to be but little affected by the seasons.

In addition to the two wells here described, there are four other deep wells within the corporate limits of Austell. Two of these are within a few hundred feet of the railroad station; they are used chiefly for domestic purposes. One of them has a depth of 150 feet, and the other, 133 feet. In the deeper well which is six inches in diameter, the water rises to within 15 feet of the surface, or ten feet higher than in the shallower well. Each well is said to furnish several gallons of water per minute. The water is derived from small seams or fissures in the gneissoid rock, at various depths from the surface. The water appears to be comparatively free from minerals. It is soft and well suited to domestic purposes. One of the other wells above referred to, is located at the Lithia Springs hotel. This well, which was completed in 1901, is located in the back-yard of the hotel. It is five and a half inches in diameter and 150 feet deep, and it is said to furnish ten gallons of water per minute. The water is soft, and is considered quite wholesome. It is said to enter the well from fissures in the gneissoid rock. The fourth well, above referred to, is the Brunk well near Spring Street, about half-a-mile south of the station. This well, which was completed in May, 1903, is six inches in diameter and 110 feet deep. The water-supply is reported to come from fissures in the gneissoid granite, struck at 35 and 100 feet from the surface, the main supply being from the deeper fissures. The well is said to furnish about ten gallons of water per minute. The water is soft; and it is used for drinking and for general domestic purposes.

The estimated amount of water given above, as furnished by the several wells, appears, in most cases, to have been made on insuffi-

cient tests. In most instances the wells are not in continuous use; and, as a result, it is not known what the actual capacity of the wells would be, if subjected to continuous tests for a long period.

Departing somewhat from the order of discussing the underground waters of the Crystalline area of the State, as previously outlined, there is here introduced the description of two shallow wells, that have recently been completed in the vicinity of Austell. These wells are here described, because they are drilled wells, and differ from the other wells of the district only in depth and in the higher mineralized conditions of their waters.

The Medlock well, the first of these wells put down, is located near the left bank of Sweetwater Creek, five-eighths of a mile northwest of the Austell station, and only a few hundred yards southwest of the "Sulpho-Magnesia Artesian" well. The Medlock well, which was completed in May, 1903, is six inches in diameter and 65 feet deep. The water, which is highly impregnated with sodium chloride (common salt), is obtained from a fissure near the bottom of the well. The supply is said to be several gallons per minute. The water rises to within five feet of the surface. The formations, penetrated in the well, consisted first of an alluvial deposit, five feet thick, followed by compact gneissoid-granite. The character of the water from this well is shown by the following analysis, made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	26.20	1.528
Sulphur Trioxide	641.60	37.417
Carbon Dioxide	93.38	5.446
Phosphorus Pentoxide	0.11	.006
Chlorine	4,769.26	278.144
Iron Sesqui-oxide and Alumina.....	18.40	1.073
Manganese	trace	trace
Lime	667.05	38.901
Magnesia	89.20	5.202
Potash	77.47	4.518
Soda	3,759.19	219.228
Lithia	14.45	.843

<i>Probable Combinations</i>	Parts per Million	Grains per U. S. Gallon
Lithium Chloride	41.86	2.441
Potassium Chloride	122.80	7.161
Sodium Chloride	7,093.80	413.696
Sodium Phosphate	0.20	.012
Magnesium Carbonate	267.60	15.607
Calcium Sulphate	787.40	45.920
Calcium Carbonate	40.70	2.782
Calcium Chloride	634.40	36.997
Manganese Carbonate	trace	trace
Total Solids	9,058.00	528.244
Free Carbon Dioxide	93.38	5.446

The Medlock well is located within a few rods of the old Medlock Spring, which is no longer used, but which formerly had considerable local reputation as a mineral spring.

The Louch well, the second of the shallow wells, is the J. H. Louch well. This well was completed October, 1903. It is located about a hundred yards from the Medlock well. The Louch well is six inches in diameter and 80 feet deep; and it furnishes about 1,500 gallons of water in 24 hours. The water rises to within five feet of the surface. The rocks penetrated by this well are practically the same as in the Medlock well. The Louch well, at present, puts on the market daily about 150 gallons of water, which is used chiefly for medicinal purposes.

An analysis of the water from this well, made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia, is as follows:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	11.60	.677
Sulphur Trioxide	485.15	28.293
Carbon Dioxide	95.79	5.581
Phosphorus Pentoxide	trace	trace
Chlorine	3,134.16	182.777
Bromine	2.82	.121
Iron Sesqui-oxide .....	.64	.037
Alumina .....	.40	.023



THE RESERVOIR AT MONTEZUMA, MACON COUNTY, GEORGIA, SHOWING SUPPLY-PIPES FROM ARTESIAN WELLS.



	Parts per Million	Grains per U. S. Gallon
Manganese	trace	trace
Barium Oxide	0.25	.015
Lime	276.21	16.107
Magnesia	44.43	2.591
Potash	76.94	4.487
Soda	2,687.58	156.734
Lithia	8.76	.511

Probable Combinations

Lithium Chloride	24.67	1.430
Potassium Chloride	119.50	6.969
Potassium Bromide	4.20	.245
Sodium Chloride	5,070.90	295.725
Sodium Phosphate	trace	trace
Magnesium Sulphate	133.30	7.774
Calcium Sulphate	670.80	39.120
Barium Sulphate .....	.38	.022
Aluminum Sulphate	1.36	.079
Iron Carbonate	1.22	.071
Total Solids	6,096.00	355.507
Free Carbon Dioxide	70.10	4.088

The waters from the last two described wells, and also the water from the "Artesian Lithia" well, are rather remarkable waters, on account of the high percentage of sodium chloride. This is especially true, when it is taken into consideration, that the water, in each case, is obtained from gneissoid-granite rocks, and that all the rocks for miles around are all highly crystalline.

DOUGLAS COUNTY

THE SWEETWATER PARK HOTEL WELL. — Two deep wells are reported to have been sunk in Douglas county, one at Douglasville, and the other at Sweetwater Park hotel. The latter was put down in May, 1898, in order to obtain water for the hotel. This well is six inches in diameter and 539 feet deep. It cost about \$3,500. It furnished, when first completed about five gallons of water per minute. The water, which rises to within 20 feet of the surface, is said

to be soft, and well suited for general domestic purposes. The well penetrated gneissoid granite its entire depth. The water enters the well by several fissures, struck at various depths. The water-supply of the well being insufficient to supply the hotel, the well has been abandoned.

The Douglasville well, which is owned by Mr. J. B. Duncan, is said to have attained a depth of 125 feet without securing water. This well, judging from the geology of the surrounding country, penetrated granite or gneiss its entire depth.

TROUP COUNTY

WEST POINT DEEP WELLS.—Probably the most satisfactory deep wells, so far constructed in the Crystalline area of Georgia, is the group of wells belonging to the Lanette Cotton Mills at West Point. These wells, which are located on the second bottom of the Chattahoochee River, are seven in number. Each well has a diameter of eight inches; but they are quite variable in their depth, as well as in the water-supply, as may be seen by the following table:—

No.	Depth	Gallons Per Minute
1	150 feet	50
2	903 "	15
3	506 "	98
4	604 "	75
5	550 "	45
6	225 "	25
7	250 "	20 (?)

These wells are all located within 250 yards of the river, and within an area, whose radius does not exceed 200 feet. The pumping of one well, with only two exceptions, is said not to affect the static head of the water in the other wells. This appears to be due to the water-bearing seams in each well being largely independent, and having no immediate connection with the water-bearing seams of the other wells. The water from all of the wells, however, seems to have about the same mineral constituents. Mr. Lanier, President of

the Lanette Cotton Mills, in speaking of the character of the water from these wells, says: — "The water is quite pure, and well suited both for bleaching and dyeing purposes, for which it is chiefly used."

All the West Point wells penetrate practically the same formations. These formations consist of alluvial deposits and decomposed rocks to a depth, varying from 60 to 100 feet, followed by crystalline rocks, chiefly gneisses, to the bottom of the wells. The water, which in most cases rises to within a few feet of the surface, enters the well by fissures or cracks in the gneisses at various depths. One well, when first completed, is said to have furnished a small flow. The surface of the alluvial soil, at the point where the wells are located, is only a few feet above the high-water mark of the Chattahoochee River.

McDUFFIE COUNTY

THE THOMSON DEEP WELL. — The only deep well reported in McDuffie county is located at Thomson, the county seat. The Thomson deep well, which was put down by the town authorities in 1902, at a cost of about \$2,500.00, varies from six to eight inches in diameter, and attains a depth of 506 feet. The water rises to within ten feet of the surface; but during wet weather it is said to furnish a slight flow.

The formation penetrated by the well is reported as follows: —

1	Bluish clay	23	feet
2	Yellowish clay	50	"
3	Decomposed granite	10	"
4	Granite with occasional fissures.....	423	"

The first 75 feet of this well penetrates clays, which are probably Cretaceous, or of a more recent age. The granite below, from which the water comes has a gneissoid structure. It is rather coarse-grained; but, otherwise, it differs but little from the granites of the Crystalline area. Three water-bearing fissures are reported in the well at 125, 327 and 450 feet, respectively, the main water-supply being derived from the two lower fissures. The well supplies daily about 12,000 gallons, which is used mainly for drinking purposes.

An analysis of the water from the Thomson well, made by Mr. J. M. McCandless, State Chemist, is as follows:—

	Parts per Million	Grains per U. S. Gallon
Sodium Chloride	5.45	.3177
Sodium Sulphate	7.31	.4263
Sodium Carbonate	30.77	1.7944
Potassium Carbonate	6.68	.3896
Calcium Carbonate	47.94	2.7957
Magnesium Carbonate	7.26	.4234
Oxides of Iron and Alumina.....	1.60	.0933
Silica	31.60	1.8428
Total	138.61	8.0832

Sanitary Analysis

Free Ammonia .....	.012
Albuminoid Ammonia .....	.036
Nitrogen as Nitrates	none
Nitrogen as Nitrites	none

In addition to the deep wells of the Crystalline area, here described, the deep wells of Macon and Augusta, as has been before noted under the description of the deep wells of the Coastal Plain, may also be considered as belonging to the Crystalline area, as they all penetrate in their lower depths the Crystalline rocks. Nevertheless, as the water-supply from these deep wells is probably, in a great measure, derived from the superficial beds of the Coastal Plain sands and clays, it is thought best to describe them as belonging to that physiographic division. It is likely, that there are several other deep wells in the Crystalline area besides the ones above described. However, no definite information has been obtained, in regard to such wells.

SHALLOW WELLS

As elsewhere stated in this report, the shallow wells of the Crystalline area are the main source of domestic water-supply, not only for the rural districts, but also for the majority of the small towns. The water, supplying these wells, is from two sources, namely, the residual clays, and the alluvial deposits in the valleys of the larger streams.

WELLS IN ALLUVIAL CLAYS. — The number of wells receiving their water-supply from alluvial clays is not great; but, at the same time, this class of wells requires special attention, on account of the liability of the water becoming contaminated by surface sewage. In general, the conditions commonly met with in these wells, may be summed up as follows: — Many of the rivers and larger streams of the Crystalline area traverse valleys of erosion, which vary from a few hundred feet to half-a-mile or more in width. These valleys, parts of which now frequently lie several feet above the present flood-plain of the rivers, are usually covered to a depth of many feet by alluvial deposits, left by the streams when they flowed at a higher level. The deposits are usually in two layers. The lower layer, which lies directly upon the eroded upturned edges of the underlying Crystallines, consist chiefly of coarse, water-worn gravel and rounded boulders. This layer varies in thickness from a few inches to several feet, depending somewhat upon the irregular eroded surface of the underlying rocks. The upper layer, which is generally much thicker than the lower layer, is made up of silt, or sandy clays. The two layers are conformable, and correspond in dip with the slope of the eroded surface of the underlying rocks, thus giving to the entire surficial deposit a gradual slope to the center of the valley.

It often happens, that the upper of the two alluvial beds has been removed by erosion along the margin of the valleys, thereby exposing the underlying gravel beds. The exposed edges of these gravel beds present a most favorable condition for taking up the surface waters as they escape to the valleys from the adjacent hillslopes, after a passing shower. Owing to the porous and open condition of these beds, they form very imperfect filters; and, as a consequence, wells obtaining their water-supply from such beds are quite likely to become contaminated with surface impurities. Many of the smaller towns of the Crystalline area of North Georgia, located in the river valleys, depend almost entirely upon wells penetrating the above described alluvial deposits for water. In laying out these towns, it has been the usual plan to locate the business houses and the residences near the center of the valley; and the barns, stables, etc., along the margin of the valley, near the line of outcropping of the gravel beds which supply the wells with water.

Two towns, located along the Atlanta, Knoxville & Northern division of the Louisville & Nashville Railroad, were selected for special study. They obtain their water-supply chiefly from shallow wells, with geologic conditions similar to those named above. Both of these towns, namely, Ellijay and Canton, are located in river valleys; and they depend mainly on shallow wells, sunk into alluvial deposits for domestic water-supply. Ellijay, the county-seat of Gilmer county, is located at the confluence of the Cartecay and Ellijay rivers. It is a typical mountain town, of about 600 inhabitants; and, for many years, it has been much frequented in summer by people from the southern part of the State.

The town has experienced, once or twice, very serious epidemics of typhoid fever. The writer was informed by one of the leading physicians of the town, that, during the rage of this disease, some 10 or 15 years ago, not a family in the town escaped. With probably a half-dozen exceptions, the entire population depends upon shallow wells for drinking water. These wells vary from 25 to 35 feet in depth; and they usually penetrate, near the bottom, a layer of water-worn gravel or of coarse sand, from which the main supply of water is generally obtained. Overlying the water-worn gravel or sand, occurs a bed of river silt. This bed, when not partially removed by erosion, often attains a thickness of 15 feet or more. The wells all furnish a good supply of water, but they are more or less affected by long droughts. During the month of September, 1903, the writer secured samples of water from several of these wells, and submitted them to Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia, for analyses, with the following results:—

<i>Sanitary Analyses</i>	<i>Parts per Million</i>				
	1	2	3	4	5
Free Ammonia.....	0.04	0.044	0.04	0.02	0.083
Albuminoid Ammonia	0.06	0.340	0.08	0.04	0.290
Chlorine	7.00	23.100	7.50	6.00	15.400
Nitrites	0.02	—	0.01	trace	—
Nitrates	0.50	—	0.60	0.50	—
Oxygen Required to Oxidize Organic Matter	2.00	4.500	2.50	1.50	7.000

	Parts per Million				
Hardness	20.00	38.000	22.00	19.00	47.500
Organic and Volatile					
Matter	25.00	34.000	27.00	24.00	40.000
Mineral Matter	74.00	87.000	78.00	73.00	74.000
Total Solids	99.00	131.000	105.00	97.00	114.000

1 The Cox well; 2 The Public well; 3 The Kelley well; 4 The Watkins well; 5 The Hyatt Hotel well.

By an examination of these analyses, it will be noted, that there are evidences of contamination in the water from each well. This is especially true of wells Nos. 2 and 5.¹

The shallow wells, which supply the town of Canton, penetrate alluvial deposits, similar to those penetrated by the Ellijay wells. This town has also had an epidemic of typhoid fever. In the fall of 1903, at the time the writer visited the town to examine the wells, he was informed by the mayor, that there were then 17 cases of typhoid fever within the corporate limits. The following analyses of the water from three of the wells of Canton, located in different portions of the town, made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia, show evidence of surface contamination:—

	Parts per Million		
<i>Sanitary Analyses</i>	1	2	3
Free Ammonia	0.01	0.16	0.02
Albuminoid Ammonia	0.05	0.10	0.24
Chlorine	6.30	7.00	28.70
Oxygen Required to Oxidize Organic			
Matter	1.00	1.00	7.50
Hardness	19.00	19.00	34.00
Organic and Volatile Matter	19.00	19.00	28.00
Mineral Matter	40.00	42.00	90.00
Total	59.00	61.00	118.00

These sanitary analyses, together with the occasional development of epidemics of typhoid fever in towns obtaining their water-supply from shallow wells penetrating alluvial deposits, would seem to indicate, that wells of this class are often objectionable, and can

¹ Since the above was written the hotels of the town have put in private water-works and they are now supplied from a spring located on the mountain-side some distance beyond the corporate limits.

not always be considered as healthful sources of drinking water for towns. Especially is this true of towns unsupplied with sewerage systems.

WELLS IN RESIDUAL CLAYS. — The other class of wells, above referred to, namely, shallow wells, which obtain their water-supply from the residual clays, are the main source of domestic water-supply throughout the Crystalline area. These wells vary in depth from 20 to 80 feet, the average depth being probably about 35 feet. Occasionally, wells of this class are met with, attaining a depth of 90 to 100 feet; but such wells are rare, and are usually located on ridges or hills, which rise many feet above the general stream-level. In digging this class of wells, which are generally from three to four feet in diameter, there is usually encountered for the first 10 or 20 feet, a reddish or grayish sandy, micaceous clay, often containing numerous fragments of quartz which have resulted from the breaking down of the quartz veins. Beneath this heterogeneous material, which is the advanced stage of decay of the underlying crystalline rocks, is a medial stage of decay. This material, which is partially decomposed earthy rock, still retaining its original structure, is the main source of the water-supply of the shallow wells of the Crystalline area. In some instances, the water is obtained from the more compact and unweathered rocks below; but the percentage of wells, receiving their water-supply from this source, is comparatively small.

The amount of water, furnished by the wells, is variable, depending somewhat on their depth, the dryness or wetness of the seasons, and the character of the water-bearing bed. Shallow wells, during continued droughts, often become dry, while deep wells continue to furnish water, though often in reduced quantity. In general, it might be said, however, that the shallow wells of the Crystalline area usually furnish ample water throughout the year, to supply the needs, for all domestic purposes, in the small towns, and for farm uses. In some localities, where the conditions appear to be unusually favorable, the wells furnish sufficient water for operating gins and small factories. Such wells, however, may be said to be the exception, rather than the rule.

The water from the wells is usually soft, and carries less than six grains of mineral matter per gallon. During the dry season,



ARTESIAN WELL ON THE PROPERTY OF MR. E. J. WILSON, MONTEZUMA, MACON COUNTY, GEORGIA, THE FLOW OF WHICH RISES TO A HEIGHT OF 60 FEET ABOVE THE SURFACE.



when the water in the wells is low, it frequently becomes turbid, and filled with floating scales of mica. This is especially true of the shallower wells, which are not properly curbed. The sanitary condition of the water from some of these wells has been investigated; and, in some instances, the water has been found to show evidence of contamination. The cause of this contamination, in most cases, was undoubtedly due to the improper care of the wells. No precaution was taken to prevent water spilt about the surface from running back into the well, carrying with it more or less organic matter, collected from the well covering and near-by soil. The wooden curbing, noted in one case, was allowed to decay, and furnished food and lodgment for slugs and wood ants, whose bodies, from time to time, fell into the water to undergo putrefaction. These sources of contamination are purely accidental, and they would not occur in wells properly cared for.

There seem to exist in the Crystalline area no geological conditions whatever, that would appear to be favorable to the surface contamination of shallow wells. On the contrary, the conditions seem to be very favorable for complete filtration. In order that the water may reach these wells, it has to pass, as a general rule, through several feet of sandy clay, which forms a very effective filter. There are, no doubt, many of these wells, which furnish unwholesome water; but, in the majority of cases, this is due solely to improper attention, and not to natural conditions which can not be remedied.

SPRINGS

The springs of the Crystalline area are here considered under two separate headings; namely, common springs and mineral springs. Common springs, as here used, include those springs, whose waters contain a normal amount of the usual mineral constituents; while mineral springs include those, whose waters generally contain an abnormal amount of mineral constituents, and are used for the internal and external treatment of diseases. Springs of the former class are everywhere abundant throughout the Crystalline area, and furnish, in the aggregate, an enormous amount of water, suitable for domestic and manufacturing purposes. The latter springs, on the other hand, are only occasionally met with. Nevertheless, they

are of considerable economic importance, on account of their reputed medicinal properties.

The classification of springs, as here made, is probably of little scientific value, owing to the great difficulty of defining the normal and abnormal mineral constituents. However, this difficulty is largely overcome, if the uses of the water are taken into consideration. All springs, whose waters are well known for their healing properties, though they may contain only a normal amount of mineral constituents, will be considered under the head of *mineral springs*, and all others, under the head of *common springs*.

COMMON SPRINGS

Some idea may be had of the large number of common springs of the Crystalline area, when it is stated, that **nearly** every land-lot, of 160 acres, throughout the area has one or more of these springs. It is true, that the majority of the springs are small, and furnish only a few hundred gallons of water daily; yet they are usually of sufficient size, to supply an abundance of water for farms and for general domestic purposes. Many of these springs are but little affected by droughts. This is especially true of the springs located in the valleys and along the streams, with their outlet many feet below the general level of the surrounding country. The character of the water from the springs, coming, as it does, from the fissures and seams in the granites, gneisses, schists and quartzites, is almost invariably soft. Some idea may be formed of the amount and the nature of the mineral constituents of these waters, by an examination of the two following analyses, made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	25.50	1.487
Sulphur Trioxide	5.60	.327
Carbon Dioxide	58.80	3.429
Phosphorus Pentoxide	0.11	.064
Chlorine	5.10	.297
Iron Sesqui-oxide	0.70	.040

UNDERGROUND WATERS OF THE CRYSTALLINE AREA 219

	Parts per Million	Grains per U. S. Gallon
Alumina	0.80	.047
Lime	4.90	.286
Magnesia	3.00	.175
Potash	4.00	.233
Soda	9.50	.554

Probable Combinations

Potassium Chloride	6.30	.367
Sodium Chloride	3.50	.204
Sodium Sulphate	9.94	.580
Sodium Phosphate	0.20	.012
Sodium Carbonate	3.54	.206
Magnesium Carbonate	6.60	.385
Calcium Carbonate	8.75	.510
Total Solids	63.83	3.721
Free Carbon Dioxide	49.90	2.910

	Parts per Million	Grains per U. S. Gallon
<i>Constituents Determined</i>		
Silica	15.45	.901
Sulphur Trioxide	11.00	.641
Carbon Dioxide	80.40	4.689
Phosphorus Pentoxide	trace	trace
Chlorine	5.60	.327
Iron Sesqui-oxide	2.60	.151
Alumina .....	.30	.017
Lime	7.00	.408
Magnesia	1.55	.090
Potash	2.04	.119
Soda	6.89	.402

Probable Combinations

Potassium Chloride	3.24	.189
Sodium Chloride	6.70	.391
Sodium Sulphate	7.65	.446
Magnesium Sulphate	4.65	.271
Calcium Sulphate	6.10	.356
Calcium Carbonate	8.02	.468
Aluminum Sulphate	1.00	.058
Iron Carbonate	3.80	.222
Total Solids	56.61	3.302
Free Carbon Dioxide	74.44	4.399

The first analysis above given is from water obtained from what is known as the Cascade Spring, located on the Battle Hill road, six miles southwest of Atlanta. The water has a considerable local sale in Atlanta as a pure drinking water. The second analysis is from a sample of water obtained from Mr. J. H. Dockins' spring, located near Tampa, six miles northwest of Atlanta. The spring furnishes about 10 gallons per minute. The water from this spring has also a considerable sale in Atlanta as a drinking water; and it is at present sold under the name of "Crystal Spring Chalybeate-Lithia Water."

The total amount of mineral materials found in the waters of these two springs is probably somewhat lower, than the average for the small springs of the Crystalline area. Nevertheless the kinds and the relative proportions of the mineral constituents, as here shown, are probably quite constant for all such springs throughout the area.

In addition to the lesser springs, above referred to, there are, as is elsewhere noted in this report, a limited number of large springs to be found in the Crystalline area. These springs are generally met with, in the vicinity of quartzites, or rocks having an undoubted clastic origin. They are often located at the base of rather prominent ridges or hills, whose summits evidently form the catchment area for these waters. Some of the most noted of these springs occur along the base of Pine Mountain, in the southeastern portion of the Crystalline area. Two of these springs, on account of their large size, are here described in detail.

COLD SPRING, the most noted of the two springs, here referred to, and the largest spring to be found in the Crystalline area, is located near Bullochville, at the base of Pine Mountain, a quartzite ridge in the southern part of Meriwether county. The spring, which at present furnishes water for the United States Fish Hatchery, located at that point, has a daily capacity of 2,916,000 gallons. The water escapes to the surface in a number of "boils," which continuously agitate the white sand, that covers the bottom of the large artificial basin, which is surrounded by a substantial wall of masonry. Escaping with the water from the various "boils," there is to be seen from time to time bubbles of gas rising to the surface.

According to Prof. A. Means,¹ formerly of Emory College, Oxford, Ga., this gas is carbon dioxide; and, from a surface of five square feet, it amounts to 4,341 cubic inches per hour.²

An analysis of this water, made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia, shows it to contain mineral constituents, as follows:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	10.10	.589
Sulphur Trioxide	trace	trace
Carbon Dioxide	57.60	3.359
Phosphorus Pentoxide	none	none
Chlorine	4.76	.278
Iron Sesqui-oxide	1.40	.082
Alumina .....	.100	.006
Lime	1.00	.058
Magnesia	1.30	.076
Potash	1.64	.096
Soda	9.54	.556
<i>Probable Combinations</i>		
Potassium Chloride	2.59	.151
Sodium Chloride	5.80	.338
Sodium Sulphate	trace	trace
Sodium Carbonate	11.06	.645
Magnesium Carbonate	2.73	.159
Calcium Carbonate	1.80	.105
Iron Carbonate	2.03	.118
Total Solids	36.21	2.111
Free Carbon Dioxide	50.00	2.916

Blue Spring, the other large spring, above referred to, is also located at the base of Pine Mountain, in Harris county, about six miles southwest of Hamilton, the county seat. The water rises to the surface from a large circular, funnel-shaped cavity, varying from two to eight feet in diameter, and having a depth of many feet. The form of this spring is not unlike those frequently met with in limestone regions, and usually designated as "well springs,"

¹ White's Statistics of Georgia, p. 425, 1849.

² A recent examination of the gas from the Cold Spring by Dr. Everhart shows that it is only air.

on account of the shape of the cavity, through which the water ascends to the surface. The capacity of the spring is about 1,000,000 gallons per day. The water is always clear, and is said to be but little affected by the seasons. There is a plan on foot, at present, to pipe the water of this spring to Columbus, 17 miles distant, to supply the city with water. An analysis of the water, made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia, is as follows:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	14.80	.861
Sulphur Trioxide	4.09	.238
Carbon Dioxide	72.60	4.234
Phosphorus Pentoxide	trace	trace
Chlorine	4.80	.280
Iron Sesqui-oxide and Alumina.....	4.62	.269
Lime	8.63	.503
Magnesia	1.06	.062
Potash	2.78	.162
Soda	9.03	.527
<i>Probable Combinations</i>		
Potassium Chloride	4.41	.257
Sodium Chloride	4.45	.259
Sodium Sulphate	7.26	.423
Sodium Phosphate	trace	trace
Sodium Carbonate	6.00	.350
Magnesium Carbonate	2.22	.129
Calcium Carbonate	15.41	.899
Total Solids	59.17	3.451
Free Carbon Dioxide.....	62.04	3.618

Other large springs of the Crystalline area occur in Hall and other counties in the northern part of the State.

MINERAL SPRINGS

The mineral springs of the Crystalline area are quite numerous; but comparatively few of them have, so far, attained anything like a national reputation. This is due, not so much, probably, to the

character of the waters themselves, as to the lack of business enterprise in the owners, in not presenting the merits of the waters to the public. In a few cases, where the management of these springs has been in the hands of business men, they have been the source of an ever increasing revenue to their owners. This is especially true of those springs, whose waters have been offered on the market, supported by the analysis of some reputable chemist. One great difficulty with the owners of this class of springs is, that they make such unreasonable claims for their waters, that the public has become more or less skeptical as to their healing properties. It is no uncommon thing to see, in the advertisements of such springs, certificates stating that the water has accomplished some remarkable cure, when an analysis of the water shows that it is practically impossible for it to have produced any such therapeutic effect.

In the description of the mineral springs, which follows, the writer has confined himself entirely to description of the springs, their improvements, and the chemical composition of their waters, without any consideration of their medicinal qualities.¹ It should be remembered, that the list of mineral springs, here described, is not complete; nevertheless, it includes a large majority of those which have become more or less noted for their real or supposed therapeutic value.

INDIAN SPRING. — This spring is located near the main line of the Southern Railway in Butts county, 37 miles northwest of Macon. Prior to the settlement of this part of the State by the white people, this spring is said to have had quite a reputation among the Indians, on account of the healing qualities of its waters. This statement is substantiated by the fact, that, during the treaty of 1821 with the whites, the Creek Indians, then inhabiting that region, reserved the right to the spring, together with 1,000 acres in the immediate vicinity. After the removal of the Indians from Georgia, the spring, together with the 1,000 acres of land, became the property of the State. Subsequently, all the land was disposed of to individuals, except eight or ten acres immediately surrounding the spring, which

¹ A special report on the mineral waters of the State is soon to be issued by the State Geological Survey, which will discuss the therapeutic effect of the mineral waters.

is still the property of the State. The State, at present, leases the property to parties, who, within the last few years, have constructed, within a few hundred feet of the spring, an excellent hotel having accommodations for 300 guests.

The spring flows from a small fissure in the gneissoid rock, at the base of a low elevation, on which the hotel is situated. The capacity of the spring is less than a gallon per minute. The water has a distinct odor of hydrogen sulphide; and it forms, in the bottom of the shallow basin into which it flows, a slight precipitate of sulphur, of a grayish or whitish color.

The mineral constituents of the water are shown by the following analysis by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	23.50	1.370
Sulphur Trioxide	21.16	1.234
Carbon Dioxide	62.86	3.666
Phosphorus Pentoxide .....	.40	0.025
Chlorine	14.70	.857
Arsenic	trace	trace
Iron Sesqui-oxide and Alumina.....	1.00	.058
Lime	17.12	.998
Magnesia	3.30	.192
Potash	2.74	.160
Soda	40.69	2.373
Lithia .....	.046	.002
<i>Probable Combinations</i>		
Lithium Chloride	0.13	.007
Potassium Chloride	4.25	.248
Sodium Chloride	20.71	1.208
Sodium Sulphate	37.56	2.190
Sodium Phosphate	0.92	.054
Sodium Carbonate	22.75	1.327
Magnesium Carbonate	6.93	.404
Calcium Carbonate	30.57	1.783
Total Solids	147.40	8.596
Free Carbon Dioxide.....	36.34	2.119

POWDER SPRINGS. — This group of mineral springs is located at



PUBLIC ARTESIAN WELL AT OGLETHORPE, MACON COUNTY, GEORGIA.



Powder Springs station, on the Southern Railway, in the south-western corner of Cobb county. They have been known for more than 50 years, but their reputation is only local. The springs are all small, none of them furnishing more than a gallon or so per minute. The waters from springs Nos. 1 and 2, located near Powder Springs Creek, have a slight odor of hydrogen sulphide.

Analyses of the waters from three of these springs, made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia, are as follows:—

SPRING NO. I		
<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	24.20	1.411
Sulphur Trioxide	75.00	4.374
Carbon Dioxide	105.90	6.176
Phosphorus Pentoxide	—	—
Arsenic	—	—
Chlorine	107.80	6.287
Hydrogen Sulphide	1.00	.058
Alumina	1.00	.058
Iron .....	.04	.023
Lime	38.80	2.263
Magnesia	7.90	.461
Potash	4.80	.280
Soda	95.40	5.564
Lithia .....	.012	.007
<i>Probable Combinations</i>		
Lithium Chloride	0.04	.003
Potassium Chloride	7.50	.437
Sodium Chloride	171.70	10.013
Sodium Sulphate	10.20	.595
Sodium Phosphate	—	—
Sodium Carbonate	none	none
Magnesium Sulphate	16.40	.956
Magnesium Carbonate	5.00	.292
Calcium Carbonate	none	none
Aluminum Sulphate	3.30	.192
Iron Carbonate	1.00	.058
Total Solids	433.83	25.591
Free Carbon Dioxide	103.30	6.024

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SPRING NO. 2

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	34.90	2.035
Sulphur Trioxide	61.00	2.557
Carbon Dioxide	60.40	3.522
Phosphorus Pentoxide	trace	trace
Arsenic	trace	trace
Chlorine	84.00	4.899
Hydrogen Sulphide	1.00	.058
Alumina	1.50	.087
Iron	1.00	.058
Lime	37.20	2.169
Magnesia	8.20	.478
Potash	5.70	.332
Soda	105.70	6.164
Lithia .....	.09	.005
<i>Probable Combinations</i>		
Lithium Chloride .....	.028	.002
Potassium Chloride	8.70	.507
Sodium Chloride	131.30	7.657
Sodium Sulphate	82.70	4.823
Sodium Phosphate	trace	trace
Sodium Carbonate	none	none
Magnesium Sulphate	21.60	1.259
Magnesium Carbonate	3.00	.175
Calcium Carbonate	66.40	3.872
Aluminum Sulphate	3.50	.204
Iron Carbonate	2.40	.139
Total Solids	377.08	21.986
Free Carbon Dioxide	22.20	2.945

SPRING NO. 3

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	35.30	2.059
Sulphur Trioxide	11.00	.642
Carbon Dioxide	77.90	4.543
Phosphorus Pentoxide	trace	trace
Arsenic	trace	trace
Chlorine	5.60	.327

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	Parts per Million	Grains per U. S. Gallon
Hydrogen Sulphide80	.047
Alumina	1.10	.064
Iron	1.00	.058
Lime	27.50	1.604
Magnesia	10.00	.583
Potash	6.30	.367
Soda	11.50	.671
Lithia .....	.05	.003

Probable Combinations

Lithium Chloride .....	.015	.009
Potassium Chloride	10.00	.583
Sodium Chloride	1.60	.093
Sodium Sulphate	19.50	1.137
Sodium Phosphate	trace	trace
Sodium Carbonate	3.70	.216
Magnesium Sulphate	none	none
Magnesium Carbonate	21.00	1.225
Calcium Carbonate	49.10	2.863
Aluminum Sulphate	3.40	.198
Iron Carbonate	1.45	.075
Total Solids	187.00	10.905
Free Carbon Dioxide	43.80	2.554

TRENTHAM SPRING. — This spring is situated in the southern part of Campbell county, about four miles west of Fairburn, the county seat. Some years ago, the spring is said to have been quite a popular health resort; but it is now seldom visited, except by the people living in the immediate vicinity. The flow is about two gallons per minute. The water, upon standing a short time, throws down a rather copious yellowish brown precipitate of iron sesquioxide. The spring is located some distance from the nearest farmhouse, in a rather wild and picturesque section; but there are no improvements whatever about it. The hills are unusually high and steep, for that part of the State. The character of the water is shown by the following analysis, made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia: —

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	37.60	2.193
Sulphur Trioxide	18.00	1.050
Carbon Dioxide	93.60	5.459
Phosphorus Pentoxide .....	.90	.052
Arsenic	trace	trace
Chlorine	4.90	.286
Iron Sesqui-oxide	9.00	.525
Alumina .....	.63	.037
Lime	30.75	1.793
Magnesia	7.25	.423
Potash .....	.83	.048
Soda	14.90	.869
<i>Probable Combinations</i>		
Potassium Chloride	1.31	.076
Sodium Chloride	7.03	.410
Sodium Sulphate	25.58	1.491
Sodium Phosphate	1.80	.105
Sodium Arsenite	trace	trace
Magnesium Sulphate	5.39	.314
Magnesium Carbonate	11.45	.668
Calcium Carbonate	63.44	3.700
Aluminum Sulphate	2.55	.149
Iron Carbonate	12.60	.735
Total Solids	168.85	9.851
Free Carbon Dioxide.....	58.49	3.411

BOWDEN LITHIA SPRING. — The Bowden Lithia Spring, formerly known as "Salt Spring," is located near Lithia Springs station on the Southern Railway, in the northeastern part of Douglas county, 21 miles northwest of Atlanta. Prior to the settlement of this part of the country by the whites, the spring was known to the Cherokee Indians, the original inhabitants, as a "deer-lick," from the frequent visits of these animals to the spring, to lick the rocks in order to get salt.

Some years ago, shortly after the present company obtained possession of the Bowden Lithia Spring property, an effort was made to increase the capacity of the spring by blasting. The

result of this work was ruinous to the spring, owing to a stream of fresh water having been struck. This mishap led to the opening of the present spring, which is situated only a few hundred feet from the original spring. The spring, now in use, flows into a large basin blasted out of the granitoid rock, forming a reservoir. The basin is surrounded by a substantial wall of masonry, which is protected above by a glass covering. Connected with the basin is an overflow pipe and two other pipes, the latter being connected with pumps, which draw the water from the basin as it is used. The sanitary conditions of the spring seem to be well nigh perfect, and every precaution is taken to keep the water, during the rainy season, from being diluted by seepage.

The capacity of the Bowden Spring at present is about three gallons per minute. The water flows into the artificial basin through small fissures in the granitoid rock. From a financial point of view, the Bowden Lithia Spring is, so far, the most important mineral spring in the State. The water has an extensive sale throughout the South, and it is also kept on sale in many of the northern cities. During the year 1903, the aggregate value of the water shipped from the spring was more than \$25,000.

The Sweetwater Park Hotel, owned by the Bowden Lithia Spring Company, is located within a short distance of the spring. The hotel is a modern building, with every convenience, and can accommodate about 300 guests.

The mineral constituents of the Bowden Lithia Spring water are shown by the following analysis, made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	32.60	1.901
Sulphur Trioxide	151.20	8.818
Carbon Dioxide	129.80	7.570
Phosphorus Pentoxide .....	.20	.012
Arsenic .....	.10	.006
Chlorine	1,101.60	64.243
Bromine	20.70	1.207
Iron Sesqui-oxide	1.50	.087

	Parts per Million	Grains per U. S. Gallon
Alumina	2.50	.146
Manganous Oxide .....	.20	.012
Baryta .....	.20	.012
Lime	163.40	9.529
Magnesia	15.30	.892
Potash	24.50	1.429
Soda	946.00	55.169
Lithia	12.00	.700
<i>Probable Combinations</i>		
Lithium Chloride	34.00	1.983
Potassium Chloride .....	.30	.018
Potassium Bromide	30.80	1.796
Sodium Chloride	1,785.00	104.098
Sodium Sulphate .....	.30	.018
Sodium Phosphate .....	.80	.047
Sodium Arsenite .....	.40	.023
Magnesium Sulphate	45.90	2.677
Calcium Sulphate	183.90	10.725
Calcium Carbonate	156.60	9.133
Barium Sulphate .....	.30	.018
Manganese Carbonate .....	.50	.029
Aluminum Sulphate	10.90	.636
Iron Carbonate	4.40	.257
Total Solids	2,286.60	130.988
Free Carbon Dioxide	70.90	4.135

THE FRANKLIN SPRING. — The Franklin Spring is situated in the extreme southeastern part of Franklin county, about nine miles southeast of Carnesville, the county-seat. The nearest railway station is Royston, two miles distant. The spring is a rather bold chalybeate spring, located in a deep hollow near the public-road leading from Royston to Danielsville. It has quite a local reputation. The improvements consist of a few cottages and a small hotel. The water, as it flows from the spring, forms quite a precipitate of reddish-brown iron sesqui-oxide. It appears to come to the surface through fissures in the mica-schist, the prevailing rock of the region. The flow is about three gallons per minute.

An analysis of the water, made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia, is as follows:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	34.40	2.006
Sulphur Trioxide	8.24	.481
Carbon Dioxide	77.80	4.957
Phosphorus Pentoxide	trace	trace
Chlorine	6.12	.357
Iron Sesqui-oxide	12.00	.700
Alumina .....	.40	.023
Manganous Oxide .....	.30	.017
Lime	4.30	.257
Magnesia	3.75	.219
Potash	3.52	.205
Soda	14.84	.865
<i>Probable Combinations</i>		
Potassium Chloride	5.58	.325
Sodium Chloride	5.70	.332
Sodium Sulphate	12.96	.756
Sodium Phosphate	trace	trace
Sodium Carbonate	10.53	.614
Magnesium Carbonate	7.87	.459
Calcium Carbonate	7.68	.448
Manganese Carbonate .....	.48	.028
Aluminum Sulphate	1.34	.078
Iron Carbonate	17.40	1.015
Total Solids	103.94	6.061
Free Carbon Dioxide.....	65.75	3.834

PONCE DE LEON SPRING. — This spring, which is said to have been discovered about 1870, is located in the northeastern part of the city of Atlanta, in what is known as Ponce de Leon park. It is a small chalybeate spring, furnishing less than two gallons per minute. The water is used chiefly by the visitors to the park, and by the people living in the immediate vicinity. The spring, which is surrounded by a strong stone wall, flows from a fissure in the gneissoid rock, in a small ravine near the eastern margin of the park.

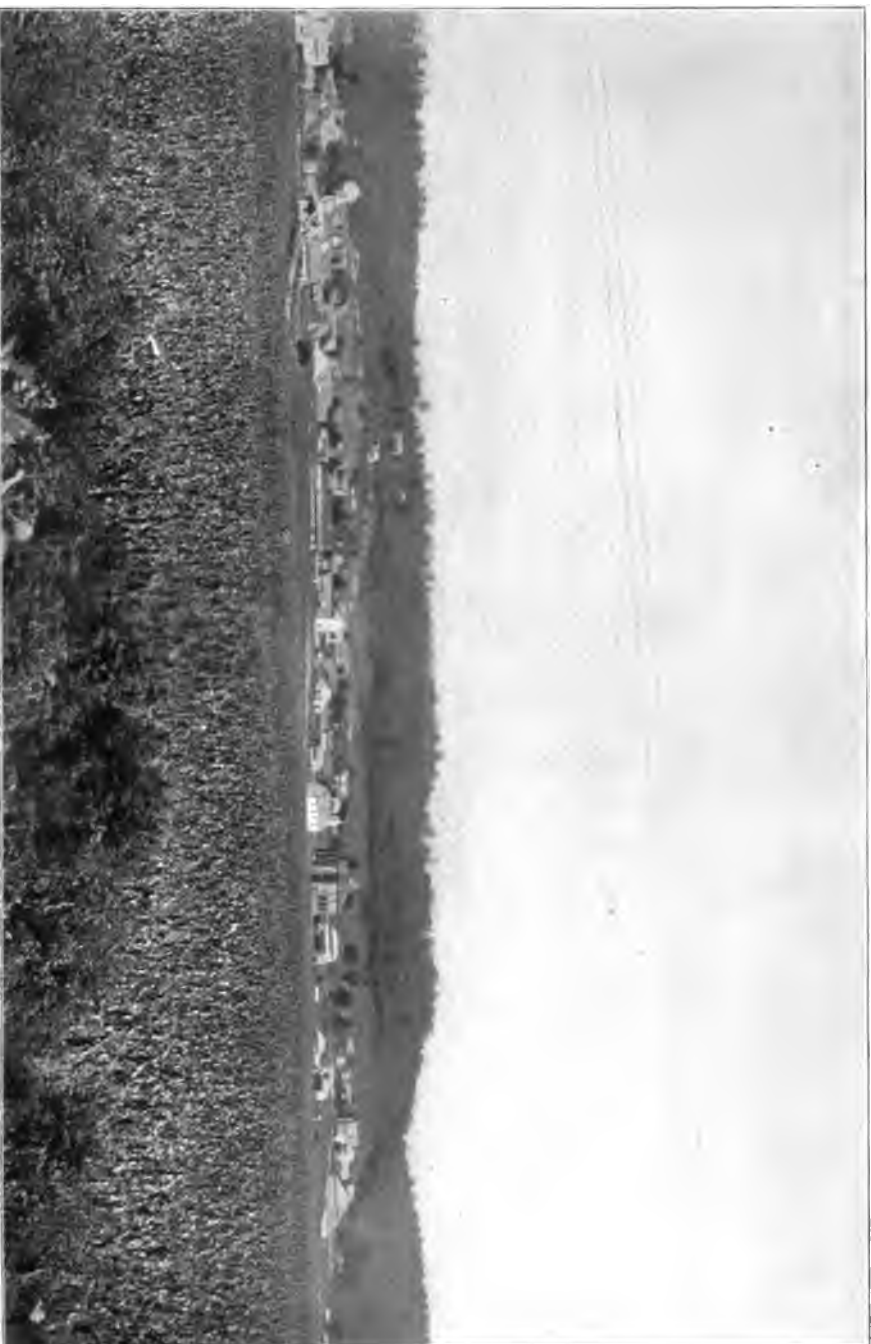
An analysis of the water, made by Dr. Edgar Everhart, in the laboratory of the Geological Survey of Georgia, is as follows:—

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<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	30.20	1.752
Sulphur Trioxide	3.50	.204
Carbon Dioxide	47.50	2.770
Phosphorus Pentoxide	trace	trace
Chlorine	6.30	.367
Iron Sesqui-oxide	5.00	.292
Alumina	0.80	.047
Lime	7.00	.408
Magnesia	4.60	.268
Potash	3.45	.201
Soda	4.70	.274
<i>Probable Combinations</i>		
Potassium Chloride	5.47	.319
Sodium Chloride	6.10	.356
Sodium Sulphate	3.39	.198
Sodium Phosphate	trace	trace
Magnesium Sulphate	2.39	.139
Magnesium Carbonate	7.98	.465
Calcium Carbonate	12.50	.729
Aluminum Sulphate	2.70	.157
Iron Carbonate	7.25	.423
Total Solids	77.98	4.538
Free Carbon Dioxide	35.07	2.045

INMAN PARK MINERAL SPRING. — The Inman Park Mineral Spring, also known as "the Spa Spring," is located in Inman Park, a beautiful residence park in the eastern part of Atlanta. The spring is small, furnishing less than one gallon a minute. It is surrounded by a heavy wall of masonry, and is apparently well protected from local surface drainage. The water, upon standing forms a heavy reddish-brown precipitate of iron sesqui-oxide. It has a slightly astringent taste; but it is otherwise a pleasant drinking water.

The mineral constituents, as shown by the following analysis by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia, are as follows: —



THE TOWN OF ELIJAY, GILMER COUNTY, GEORGIA, SITUATED ON THE EDGE OF A RIVER FLOOD-PLANE.



UNDERGROUND WATERS OF THE CRYSTALLINE AREA 233

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	7.20	.420
Sulphur Trioxide .....	.60	.035
Carbon Dioxide	33.40	1.948
Chlorine	5.50	.321
Iron Sesqui-oxide	6.60	.385
Alumina .....	.20	.012
Manganous Oxide	trace	trace
Lime	1.20	.070
Magnesia	1.22	.071
Potash .....	.20	.012
Soda	5.40	.315
<i>Probable Combinations</i>		
Potassium Chloride .....	.30	.017
Sodium Chloride	8.82	.514
Sodium Sulphate .....	.23	.013
Sodium Carbonate	1.04	.061
Manganese Carbonate	trace	trace
Calcium Carbonate	2.14	.125
Magnesium Carbonate	2.56	.149
Iron Carbonate	9.57	.558
Total Solids	32.55	1.857
Free Carbon Dioxide	27.08	1.579

SILOAM SPRING. — This spring is situated in the southeastern portion of Fulton county, near Lakewood, about four miles south of Atlanta. The spring is a small chalybeate spring, furnishing less than a gallon per minute. The water, which has a limited sale in Atlanta, has a slightly astringent taste; and it forms, upon standing, a slight reddish-brown precipitate of iron sesqui-oxide. The spring is surrounded by a stone curbing, but otherwise, there is no improvement.

An analysis of the water, made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia, is as follows: —

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	27.60	1.610
Sulphur Trioxide	1.75	.102
Carbon Dioxide	40.40	2.356
Chlorine	6.30	.367
Iron Sesqui-oxide	4.50	.262
Alumina .....	.30	.017
Lime	5.60	.327
Magnesia	4.80	.280
Potash	2.16	.126
Soda	8.48	.495
<i>Probable Combinations</i>		
Potassium Chloride	3.43	.200
Sodium Chloride	7.71	.450
Sodium Sulphate	3.23	.188
Sodium Carbonate	4.91	.286
Magnesium Carbonate	10.08	.588
Calcium Carbonate	10.00	.583
Iron Carbonate	6.98	.407
Total Solids	74.24	4.329
Free Carbon Dioxide	26.20	1.528

WHITE SULPHUR SPRING. — This spring, also called Oconee White Sulphur Spring, is located in the northeastern part of Hall county, about two miles east of White Sulphur, a small station on the Southern Railroad, six miles northeast of Gainesville. Prior to the Civil War, White Sulphur Springs is said to have been one of the most attractive watering-places in the State. At present, during the summer months, the spring is well patronized, but it has not yet regained its former popularity. The improvements consist of a hotel and a number of cottages. The spring is a small sulphur spring, furnishing less than two gallons per minute. The water has a distinct odor of hydrogen sulphide, and it forms a slight white precipitate of sulphur about the spring.

The following is an analysis of the water, made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia:—

UNDERGROUND WATERS OF THE CRYSTALLINE AREA 235

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	22.00	1.283
Sulphur Trioxide	3.64	.212
Carbon Dioxide	104.00	6.065
Phosphorus Pentoxide	trace	trace
Arsenic	trace	trace
Chlorine	5.25	.306
Iron Sesqui-oxide	1.60	.093
Alumina .....	.40	.023
Lime	22.40	1.306
Magnesia	5.59	.326
Potash	5.54	.323
Soda	38.16	2.225
Lithia	trace	trace
<i>Probable Combinations</i>		
Lithium Chloride	trace	trace
Potassium Chloride	8.78	.512
Sodium Chloride	1.76	.103
Sodium Sulphate	4.79	.279
Sodium Phosphate	trace	trace
Sodium Arsenite	trace	trace
Sodium Carbonate	60.14	3.507
Magnesium Carbonate	11.74	.685
Calcium Carbonate	40.00	2.333
Aluminum Sulphate	1.34	.078
Iron Carbonate	2.32	.135
Total Solids	130.97	7.638
Free Carbon Dioxide	54.38	3.161

GOWER SPRING. — Gower spring is located only a few hundred yards from the corporate limits of Gainesville, the county seat of Hall county. Some years ago, this was a very popular resort; but, since the destruction of the hotel by fire, the spring has been neglected, and it is now but little used. It is a small spring, furnishing less than a gallon per minute. The water, upon standing, throws down a light, reddish brown precipitate of iron sesqui-oxide.

The following analysis, made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia, shows the mineral constituents of the water: —

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	9.00	.525
Sulphur Trioxide .....	.40	.023
Carbon Dioxide	52.00	3.032
Chlorine	4.70	.274
Iron Sesqui-oxide	5.20	.303
Alumina .....	.10	.006
Lime .....	.70	.041
Magnesia	1.10	.064
Potash	1.26	.073
Soda	4.24	.247
<i>Probable Combinations</i>		
Potassium Chloride	2.00	.117
Sodium Chloride	6.28	.356
Sodium Sulphate .....	.28	.016
Sodium Carbonate	1.35	.079
Magnesium Carbonate	2.31	.135
Calcium Carbonate	1.25	.073
Aluminum Sulphate .....	.26	.015
Iron Carbonate	7.54	.440
Total Solids	30.27	1.746
Free Carbon Dioxide	47.37	2.763

GARNET SPRING. — This spring is located in the eastern part of Habersham county, about one and a half miles west of Toccoa, and only a short distance from Toccoa Falls. The spring is frequently visited by the guests of the Toccoa Falls hotel near by, and also by parties from Toccoa. The water, which is impregnated with iron salts, flows from a crevice in the gneissoid rocks. The only improvement is a rough stone wall surrounding the spring. The flow is not more than one gallon per minute. The mineral constituents of the water as shown by an analysis, made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia, are as follows: —

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	27.10	1.580
Sulphur Trioxide	10.00	.583
Carbon Dioxide	72.60	4.234
Phosphorus Pentoxide	trace	trace
Chlorine	5.25	.306
Iron Sesqui-oxide	2.20	.128
Alumina .....	.40	.023
Manganous Oxide	trace	trace
Lime	24.30	1.417
Potash	2.60	.152
Soda	8.48	.495
Magnesia	9.04	.527
<i>Probable Combinations</i>		
Potassium Chloride	4.11	.240
Sodium Chloride	5.37	.313
Sodium Sulphate	12.89	.752
Sodium Phosphate	trace	trace
Magnesium Sulphate	4.11	.240
Magnesium Carbonate	16.11	.939
Calcium Carbonate	43.40	2.531
Manganese Carbonate	trace	trace
Aluminum Sulphate	1.35	.079
Iron Carbonate	3.19	.186
Total Solids	117.63	6.861
Free Carbon Dioxide	43.85	2.557

THE WHITE PATH MINERAL SPRINGS. — The White Path Mineral Springs are located near White Path station, on the Atlanta, Knoxville & Northern division of the Louisville & Nashville Railroad, in the northern part of Gilmer county, six miles northeast of Ellijay, the county-seat. These springs are much frequented during the summer months, by parties from the southern part of the State. The location of the springs is excellent for a summer resort. They are situated at the base of one of the spurs of Turniptown Mountains, whose highest peaks attain an altitude of nearly 4,000 feet above sea-level. The temperature during the hottest days in summer is always pleasant, and the breezes from the nearby mountains are quite invigorating. The scenery, although not so

wild and picturesque as some other places in the State, is nevertheless such as is only to be met with in distinctly mountainous regions. The hills are steep and rugged, and the small streams flow in deep canyon-like gorges.

The prevailing rocks of the region are schists, slates, quartzites and conglomerates. The water of the mineral springs flows from the fissures or seams in the schists or slates. There are two of these springs, one known as the chalybeate, and the other as the magnesia spring. The former spring, which is the one chiefly used, flows from two to three gallons per minute. The water from this spring yields, upon standing a short time, a rather heavy reddish-brown precipitate of iron sesqui-hydrate. The taste is that common to chalybeate waters. The, "Magnesia" spring is a smaller spring, than the chalybeate spring. The water from this spring is not unlike the waters of common freestone springs, often met with throughout Georgia.

The improvements at White Path Mineral Springs consist of a small, poorly constructed hotel, or boarding-house, and a few cottages.

Analyses of the waters of these two springs, made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia, are as follows:—

CHALYBEATE SPRING

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	32.60	1.901
Sulphur Trioxide	11.90	.694
Carbon Dioxide	46.60	2.718
Phosphorus Pentoxide .....	.70	.041
Arsenic	trace	trace
Chlorine	4.90	.286
Iron Sesqui-oxide	4.00	.233
Alumina .....	.40	.023
Lime	15.00	.875
Magnesia	3.80	.221
Potash .....	.60	.035
Soda	11.60	.675

UNDERGROUND WATERS OF THE CRYSTALLINE AREA 239

<i>Probable Combinations</i>	Parts per Million	Grains per U. S. Gallon
Potassium Chloride .....	.95	.055
Sodium Chloride	7.33	.427
Sodium Sulphate	17.68	1.031
Sodium Phosphate	1.40	.082
Magnesium Sulphate	2.91	.170
Magnesium Carbonate	5.94	.346
Calcium Carbonate	26.80	1.563
Aluminum Sulphate	1.35	.079
Iron Carbonate	5.60	.327
Total Solids	102.56	5.781
Free Carbon Dioxide	29.50	1.720

MAGNESIA SPRING

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	10.82	.588
Sulphur Trioxide	1.25	.073
Carbon Dioxide	28.12	1.640
Phosphorus Pentoxide	none	none
Arsenic	none	none
Chlorine	3.50	.204
Iron Sesqui-oxide	2.56	.149
Alumina .....	.38	.022
Lime	3.20	.187
Magnesia	2.44	.142
Potash .....	.10	.006
Soda	3.20	.187
<i>Probable Combinations</i>		
Potassium Chloride .....	.18	.010
Sodium Chloride	5.63	.328
Sodium Sulphate .....	.46	.027
Sodium Phosphate	none	none
Magnesium Sulphate	1.19	.069
Magnesium Carbonate	4.28	.250
Calcium Carbonate	5.71	.333
Aluminum Sulphate .....	.30	.017
Iron Carbonate	3.71	.236
Total Solids	32.28	1.858
Free Carbon Dioxide	19.66	1.146

DANIEL MINERAL SPRING. — This spring is located in Green county, seven miles northeast of Union Point. It is a small spring, furnishing about one and a half gallons of water per minute. The spring has long been known; but only within the last few years has its water been placed upon the market. The annual sale of the water at present is said to be about 30,000 gallons. The chief points of shipment are Atlanta and Augusta. With the exception of one or two small cottages, there are no improvements around the spring, other than a curbing, which keeps the spring from being flooded by the creek near by, during high water.

The rocks in the vicinity of the spring consist mainly of mica and hornblende schists and gneisses.

The character of the water is shown by the following analysis, made by Dr. Edgar Everhart, in the laboratory of the Geological Survey of Georgia: —

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	43.20	2.519
Sulphur Trioxide	933.60	54.446
Carbon Dioxide	95.40	5.564
Phosphorus Pentoxide .....	.20	.012
Chlorine	7.50	.437
Iron Sesqui-oxide	1.00	.058
Alumina .....	.50	.029
Lime	636.90	36.781
Magnesia	56.30	3.283
Potash	5.00	.292
Soda	44.40	2.589
Lithia	trace	trace
<i>Probable Combinations</i>		
Lithium Chloride	trace	trace
Potassium Chloride	7.92	.462
Sodium Chloride	6.14	.360
Sodium Sulphate	94.25	5.497
Sodium Phosphate .....	.40	.023
Magnesium Sulphate	168.60	9.832
Calcium Sulphate	1,305.10	76.111
Calcium Carbonate	177.70	10.363



CUT ALONG THE LOUISVILLE & NASHVILLE RAILROAD AT ELLIJAY, GILMER COUNTY, GEORGIA, SHOWING SECTION OF THE ALLUVIAL DEPOSITS, WHICH SUPPLY THE SHALLOW WELLS OF THE TOWN WITH WATER.



	Parts per Million	Grains per U. S. Gallon
Aluminum Sulphate	2.18	.127
Iron Carbonate	2.90	.169
Total Solids	1,808.39	105.462
Free Carbon Dioxide	26.00	1.516

PARKER MINERAL SPRING. — This is a small chalybeate spring, located about one mile north of Hamilton, the county seat of Harris county. It furnishes less than one gallon per minute. The water has a slight astringent taste; and it throws down, upon standing, a rather copious reddish brown precipitate of iron sesqui-hydrate. The spring has considerable local reputation; but, so far, it has not been improved.

The mineral constituents of the water are shown by the following analysis made by Dr. Edgar Everhart in the laboratory of the Geological Survey of Georgia:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	10.40	.607
Sulphur Trioxide .....	.82	.048
Carbon Dioxide	54.00	3.149
Phosphorus Pentoxide	trace	trace
Chlorine	4.76	.278
Iron Sesqui-oxide	7.40	.432
Alumina .....	.40	.023
Manganous Oxide	1.20	.070
Lime	1.60	.093
Magnesia	1.60	.093
Potash	2.20	.128
Soda	5.80	.338
<i>Probable Combinations</i>		
Potassium Chloride	3.48	.203
Sodium Chloride	5.16	.301
Sodium Sulphate	1.45	.084
Sodium Phosphate	trace	trace
Sodium Carbonate	4.22	.246
Magnesium Carbonate	3.36	.196
Calcium Carbonate	2.86	.167

	Parts per Million	Grains per U. S. Gallon
Manganese Carbonate	1.94	.113
Aluminum Sulphate	1.35	.079
Iron Carbonate	8.86	.517
Total Solids	43.08	2.512
Free Carbon Dioxide	45.00	2.624

PORTER SPRINGS. — This popular summer-resort is located in the northeastern part of Lumpkin county, about eight miles north of Dahlonega. Gainesville, the nearest railroad station, is 28 miles distant. The spring is situated at the base of one of the foot-hills of Cedar Mountain, a prominent peak rising 3,000 feet above sea-level. There are several excellent views in the vicinity of the spring, from which Black Mountain and other high mountains in North Georgia may be seen to the northward. From a scenic point of view, this spring is most favorably located. It is within eight miles of Blood Mountain, one of the loftiest peaks of the Blue Ridge Mountains, and is only a short distance from the Chestatee River.

The improvements at the spring consist of a hotel and a few cottages. The main part of the hotel was constructed some years ago, and is now somewhat in need of repairs.

The spring is a small chalybeate spring, furnishing only a few gallons of water per minute. The water, upon standing, throws down a rather copious reddish brown precipitate of iron sesquihydrate.

The mineral constituents of the water are shown by the following analysis, by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia: —

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	13.10	.764
Sulphur Trioxide	3.22	.188
Carbon Dioxide	34.72	2.025
Phosphorus Pentoxide	trace	trace
Arsenic	trace	trace
Chlorine	5.10	.297
Iron Sesqui-oxide	9.60	.560

	Parts per Million	Grains per U. S. Gallon
Alumina .....	.30	.017
Manganous Oxide	trace	trace
Lime	3.10	.181
Magnesia	1.70	.099
Potash !.....	1.39	.081
Soda	7.82	.456
<i>Probable Combinations</i>		
Potassium Chloride	2.20	.128
Sodium Chloride	6.67	.389
Sodium Sulphate	3.99	.232
Sodium Phosphate	trace	trace
Sodium Carbonate	4.37	.255
Magnesium Carbonate	3.57	.208
Calcium Carbonate	5.53	.322
Manganese Carbonate	trace	trace
Aluminum Sulphate	1.00	.058
Iron Carbonate	13.92	.812
Total Solids	54.35	3.168
Free Carbon Dioxide	23.33	1.361

SILAM MINERAL SPRING. — In addition to the spring, above described, there is also another mineral spring in Lumpkin county, which is said to have had, some years ago, quite a local reputation. This spring, known as Silam Mineral Spring, is located in a broken, hilly country, four miles west of Dahlonega. It is a small chalybeate spring, furnishing less than one gallon per minute. A qualitative analysis of the water, by Prof. W. J. Land, formerly State Chemist of Georgia, shows that the principal mineral constituents are iron carbonate, soda and calcium carbonate. There are no improvements, at present, about the spring. However, Col. W. P. Price, the owner of the spring, in a letter to the writer, says, that a company in New York stands ready to build a sanitorium at the spring, as soon as invalids can be transferred from Gainesville in safety.

WARM SPRINGS. — The spring, which has made this place prominent as a watering-place, is the best-known thermal spring in the State. It is located on the Southern Railway at the base of one

of the foot-hills of Pine Mountain, in the southern part of Meriwether county. This spring is one of the most noted and popular watering-places in the State. The improvements consist of a modern hotel, having a capacity for about 200 guests, a large number of neat and well constructed cottages, a livery stable, a large natatorium and numerous private baths. The grounds are well laid out and are kept in good condition. The nearness of Pine Mountain, which attains an altitude of 1,200 feet, or more, above sea-level, adds greatly to the natural beauty of the place, and at the same time produces the mountain breezes, which are so refreshing during the hot summer nights.

The spring flows from a quartzite ledge at the margin of a small meadow. The temperature of the water, taken at the point where it enters the baths, was found to be 85° F. It is said that the water, as it flows from its natural outlet into the enclosed basin, which supplies the baths, has a temperature of 90° F. This statement, however, could not be verified owing to the natural outlet being inaccessible.

The capacity of the spring is 1,890 gallons per minute. The water is always clear, and it is supposed to possess marked medicinal properties.

The mineral constituents of the water are shown by the following analysis, made by Dr. Edgar Everhart, in the laboratory of the Geological Survey of Georgia, to be as follows:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	22.75	1.327
Sulphur Trioxide	5.10	.297
Carbon Dioxide	83.10	4.846
Chlorine	4.20	.245
Iron Sesqui-oxide	1.50	.087
Alumina	1.00	.058
Lime	28.00	1.633
Magnesia	17.70	1.032
Potash .....	.35	.026
Soda	5.00	.292

<i>Probable Combinations</i>	Parts per Million	Grains per U. S. Gallon
Potassium Chloride .....	.55	.032
Sodium Chloride	4.84	.282
Sodium Sulphate	3.30	.192
Magnesium Sulphate	1.26	.073
Magnesium Carbonate	36.28	2.116
Calcium Carbonate	50.00	2.916
Aluminum Sulphate	2.70	.157
Iron Carbonate	1.80	.105
Total Solids	123.48	7.200
Free Carbon Dioxide	41.27	2.407

CHALYBEATE SPRING. — This spring, known also as the Grant Mineral Spring, is located among the foot-hills of Pine Mountain, seven miles southeast of Warm Springs, in the extreme southeastern corner of Meriwether county. The spring, some years ago, was a noted summer resort; but, at present, it is only occasionally visited by health seekers.¹

The improvements consist of several cottages and a hotel, which are all now in a more or less dilapidated condition. The main spring from which the sample of water was taken for analysis, is a bold chalybeate spring, furnishing probably ten gallons of water per minute. The water has a distinct iron taste, and deposits a rather abundant brownish precipitate of iron sesqui-hydrate.

An analysis of this water by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia, is as follows: —

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	21.00	1.225
Sulphur Trioxide	8.07	.469
Carbon Dioxide	64.90	3.785
Phosphorus Pentoxide	none	none
Chlorine	3.00	.175
Iron Sesqui-oxide	4.80	.280
Alumina .....	.80	.046

¹ Since the above notes were written the A. B. & A. Railroad has located a station at Chalybeate Spring, and it seems quite probable that the Spring will soon regain its former popularity as a watering place.

	Parts per Million	Grains per U. S. Gallon
Manganous Oxide	0.40	.023
Lime	18.69	1.090
Magnesia	10.66	.622
Potash	2.40	.140
Soda	4.20	.245
<i>Probable Combinations</i>		
Potassium Chloride	3.80	.222
Sodium Chloride	1.96	.104
Sodium Sulphate	7.26	.423
Magnesium Sulphate	6.00	.350
Magnesium Carbonate	18.18	1.060
Calcium Carbonate	30.78	1.195
Manganese Carbonate	0.79	.046
Aluminum Sulphate	2.70	.157
Iron Carbonate	6.96	.406
Total Solids	99.43	5.188
Free Carbon Dioxide	40.40	2.356

In addition to the spring, here described, there are several others in the immediate vicinity, which are said to possess mineral properties; but the waters from none of these springs were secured for analysis.

WHITE SULPHUR SPRING. — White Sulphur Spring, in Meriwether county, is located near the Central of Georgia Railway, nine miles west of Warm Springs. This spring, like the chalybeate spring of Meriwether county, was formerly a much frequented summer resort; but, at present, it is almost wholly abandoned as a watering-place. The several cottages and other buildings are greatly in need of repair.¹ The spring is a small sulphur spring furnishing less than two gallons per minute. The water has a distinct odor of hydrogen sulphide, and it forms, at a point where it overflows the basin in which it collects, a grayish-white precipitate of sulphur.

The country in the vicinity of the spring presents an undulating surface.

¹ Since the writer's visit to this spring, the property has been put in good shape, and the "Meriwether" hotel is now open to guests, under the proprietorship of Messrs. Scoville & Tigner.

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The mineral constituents of the water of White Sulphur Spring are shown by the following analysis, made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	47.10	2.747
Sulphur Trioxide	6.60	.385
Carbon Dioxide	100.00	5.832
Phosphorus Pentoxide	trace	trace
Chlorine	7.00	.408
Iron Sesqui-oxide	3.60	.210
Alumina .....	.40	.023
Manganous Oxide	trace	trace
Lime	24.50	1.429
Magnesia	6.00	.350
Potash	3.40	.198
Soda	14.26	.832
<i>Probable Combinations</i>		
Potassium Chloride	5.39	.314
Sodium Chloride	7.30	.426
Sodium Sulphate	10.03	.585
Sodium Phosphate	trace	trace
Sodium Carbonate	16.64	.970
Magnesium Carbonate	12.60	.735
Calcium Carbonate	43.75	2.551
Manganese Carbonate	trace	trace
Aluminum Sulphate	1.35	.079
Iron Carbonate	5.22	.304
Total Solids	149.38	8.711
Free Carbon Dioxide	70.48	4.110

There are three or four other springs in the immediate vicinity of the one here described, but samples of their waters were not secured for analyses.

MADISON SPRING. — Madison Spring is in the northern part of Madison county, about ten miles north of Danielsville, the county seat. Previous to the Civil War, this spring was a popular resort; but it is now only occasionally visited. The improvements, which were once quite extensive, are now all gone, except a few buildings, which are sadly in need of repair.

The spring is small, furnishing less than two gallons per minute. The water, on standing, throws down a reddish brown precipitate of iron sesqui-hydrate.

The mineral constituents of the water are shown by the following analysis, by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia: —

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	38.60	2.251
Sulphur Trioxide	9.28	.541
Carbon Dioxide	38.80	2.263
Phosphorus Pentoxide	trace	trace
Chlorine	5.25	.306
Iron Sesqui-oxide	1.00	.058
Alumina .....	.10	.006
Lime	9.10	.531
Magnesia	3.86	.225
Potash	3.04	.177
Soda	12.30	.717
<i>Probable Combinations</i>		
Potassium Chloride	5.40	.315
Sodium Chloride	4.42	.258
Sodium Sulphate	16.46	.960
Sodium Phosphate	trace	trace
Sodium Carbonate	4.72	.275
Magnesium Carbonate	8.10	.472
Calcium Carbonate	16.25	.948
Aluminum Sulphate .....	.34	.020
Iron Carbonate	1.55	.090
Total Solids	95.84	5.589
Free Carbon Dioxide	24.90	1.452

WATSON'S MINERAL SPRING. — This spring is located in the extreme southwestern corner of Oglethorpe county, eight miles west of Maxeys, a small station on the Athens branch of the Georgia Railroad. It has a considerable local reputation, and is much visited during the summer by the people of the region.

The improvements consist of a boarding-house, recently built, and a few cottages. The spring is walled and is enclosed by a small neat wooden pavilion.



DUE'S MILL SPRING, NEAR CASS, BARTOW COUNTY, GEORGIA.



The capacity of the spring is only one gallon in five minutes. The water has a faint odor of hydrogen sulphide; but it does not deposit any precipitate. The scenery in the vicinity of the spring is varied. The hills are usually well rounded and the valleys, narrow. The Oconee River, near by, presents a good opportunity for boating.

The character of the water is shown by the following analysis, made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	35.40	2.064
Sulphur Trioxide	3.00	.175
Carbon Dioxide	113.80	6.637
Phosphorus Pentoxide	trace	trace
Chlorine	3.40	.198
Iron Sesqui-oxide	1.00	.058
Alumina .....	.20	.012
Lime	48.20	2.811
Magnesia	11.50	.671
Potash	1.27	.074
Soda	16.70	.974
<i>Probable Combinations</i>		
Potassium Chloride	2.01	.117
Sodium Chloride	4.02	.234
Sodium Sulphate	4.47	.261
Sodium Phosphate	trace	trace
Sodium Carbonate	21.54	1.256
Magnesium Carbonate	24.15	1.408
Calcium Carbonate	86.07	5.016
Aluminum Sulphate .....	.68	.040
Iron Carbonate	1.45	.085
Total Solids	179.79	10.481
Free Carbon Dioxide	53.81	3.138

In addition to the spring here described, there are also other springs in the immediate vicinity, which are said to possess mineral properties; but, at the time of the writer's visit, they were not in use, and samples of the water were not secured for analysis.

TALLULAH FALLS MINERAL SPRING.—The Tallulah Falls Mineral Spring is located at Tallulah Falls, only a few rods north of the

Blue Ridge Railroad, between the Lodge and the Cliff House. The spring flows from a fissure in the gneissoid rock, near the bottom of a deep ravine, which leads down into Tallulah Gorge only a few hundred yards away. The spring furnishes less than two gallons of water a minute. It has an astringent taste, and it forms a rather copious reddish-brown deposit of iron sesqui-hydrate. The spring is unimproved; but it is much frequented by the guests of the near-by hotels.

An analysis of the water, made by Dr. Edgar Everhart, in the laboratory of the Geological Survey of Georgia, is as follows:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	8.10	.472
Sulphur Trioxide	4.25	.248
Carbon Dioxide	41.80	2.438
Phosphorus Pentoxide	trace	trace
Chlorine	2.80	.163
Iron Sesqui-oxide	9.10	.531
Alumina .....	.70	.041
Manganous Oxide	trace	trace
Lime	2.60	.152
Magnesia	1.20	.070
Soda	4.10	.239
Potash .....	.20	.012
<i>Probable Combinations</i>		
Potassium Chloride .....	.32	.019
Sodium Chloride	4.40	.257
Sodium Sulphate	4.10	.239
Sodium Phosphate	trace	trace
Magnesium Sulphate	2.93	.171
Magnesium Carbonate .....	.46	.027
Calcium Carbonate	4.64	.271
Manganese Carbonate	trace	trace
Aluminum Sulphate	2.20	.128
Iron Carbonate	13.20	.770
Total Solids	40.35	2.354
Free Carbon Dioxide	34.50	2.012

ARGON SPRING. — This spring, which is also known as the "Anti-nausea Spring," is located on the Washington branch of the Georgia

Railroad in the eastern part of Taliaferro county, about a quarter of a mile from Hillman station. It is only a few yards from the so-called Hillman electric rock, which is claimed to have performed some remarkable cures by its shocks.

The spring is situated on low ground, at the base of a hill of quartzose schist. It is surrounded by a curb, and is also protected by a small house. The flow of the spring is somewhat variable; but Mr. Hillman estimates that the average is about 150 gallons an hour. Some years ago, there was a large hotel near the spring, for the entertainment of guests; but it was destroyed by fire, and there now remain only a few small buildings.

The mineral constituents of the water are shown by the following analysis, made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	39.42	2.299
Sulphur Trioxide	1.20	.070
Carbon Dioxide	74.32	4.334
Chlorine	6.30	.367
Iron Sesqui-oxide .....	.80	.047
Alumina .....	.45	.026
Lime	10.31	.601
Magnesia	4.05	.236
Potash	2.45	.143
Soda	13.05	.761
<i>Probable Combinations</i>		
Potassium Chloride	3.89	.227
Sodium Chloride	7.32	.427
Sodium Sulphate .....	.35	.020
Sodium Carbonate	13.49	.787
Magnesium Carbonate	8.50	.496
Calcium Carbonate	18.41	1.074
Aluminum Sulphate	1.49	.087
Iron Carbonate	1.16	.068
Total Solids	104.03	5.485
Free Carbon Dioxide	55.73	3.250

EADY MINERAL SPRING. — This is a small spring located in the northern part of Heard county, on Mill Creek, only a few hundred yards from the point where it empties into the Chattahoochee River.

The spring, which furnishes only a gallon a minute, is just below a beautiful waterfall, formed by Mill Creek. The scenery is picturesque; it resembles that often met with in the more mountainous part of the State. The prevailing rocks of the region are gneiss, granite and schists. The first forms the declivity over which the creek cascades near the spring.

Some years ago, this spring is said to have had quite a local reputation; but, at present, only a few people visit it. There are no improvements in the vicinity of the spring, except a small cabin and a mill-house. The water has a faint odor of hydrogen sulphide, which entirely disappears after standing for a short time in an open vessel.

An analysis of the water, made by Dr. Edgar Everhart, in the laboratory of the Geological Survey of Georgia, is as follows:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	10.50	.612
Sulphur Trioxide	1.45	.085
Carbon Dioxide	45.57	2.658
Chlorine	6.65	.388
Iron Sesqui-oxide	8.50	.496
Alumina	0.25	.015
Manganous Oxide	trace	trace
Lime	3.65	.213
Magnesia	trace	trace
Potash	3.47	.202
Soda	9.40	.548
<i>Probable Combinations</i>		
Potassium Chloride	5.50	.321
Sodium Chloride	6.64	.387
Sodium Sulphate	2.57	.150
Sodium Carbonate	8.14	.475
Magnesium Carbonate	trace	trace
Calcium Carbonate	6.52	.380
Manganese Carbonate	trace	trace
Aluminum Sulphate .....	.78	.045
Iron Carbonate	12.32	.719
Total Solids	52.97	3.089
Free Carbon Dioxide	34.65	2.020

CHAPTER XI

DETAILED NOTES ON THE UNDERGROUND WATERS OF THE PALEOZOIC AREA

DEEP WELLS

The deep wells of the Paleozoic area are few in number. This is due to two causes: (1) the small cost of constructing shallow wells, which usually furnish ample water for household purposes; and (2) the prevailing unfavorable geologic conditions for successful flowing wells in the region.

The geologic conditions, here referred to, may be readily understood by an examination of the geologic map of the Paleozoic area by Dr. J. W. Spencer; or, what is still better, the several geologic folios of the United States Geological Survey of the region, by Dr. C. W. Hayes. It will be noticed, by an examination of these maps, that the structural geology of the region is entirely different from that of the other divisions of the State. In the Cretaceous and Tertiary areas, it has been previously pointed out, that the strata lie nearly horizontal, with a gradual dip to the southward; while, in the Crystalline area, the structure is so varied and complicated, that it is difficult, or impossible to work out. In contrast with these structures, but at the same time occupying a somewhat intermediate stage between the two types of structures, is the folded and faulted rocks of the Paleozoic area.

The region is one, in which the dynamic forces have acted with such great energy, that the limestones, shales and sandstones, with an aggregate thickness of several thousand feet, have been compressed by lateral forces into a number of huge unsymmetrical parallel folds. In some instances, where the rocks were unable to withstand the intense pressure to which they were subjected, the strata

were broken, and the tension was relieved by faulting. These faults, which often represent displacements of many hundred feet, are technically known as thrust faults. The structural conditions of the Paleozoic area, as here outlined, would seem to be not especially unfavorable for successful flowing wells. These conditions, however, have been in a great measure changed by subsequent erosion, as may be seen by an examination of the geologic sections accompanying the maps referred to above. The sections, it will be observed, show that the apices of the anticlinal folds of the region have been removed in most cases by erosion, and are now replaced by valleys, which are separated from each other by synclinal ridges. This structural condition is extremely unfavorable for flowing wells, as the outcropping of the water-bearing strata in most instances occurs along the margin of the valleys, usually at a lower level than where wells are likely to be constructed. This statement it must be borne in mind applies only to flowing wells and not to non-flowing wells. Those of the latter class would no doubt likely be more or less successful throughout the area, if driven to some depth below the level of the valleys. The water-bearing strata of the synclinal folds, whether sandstone or fissured limestone, doubtless have their interstices and cavities filled with water, up to the general level of the springs, the waters of which may be termed the natural overflow of the water-bearing strata of the synclinal folds. The deep wells therefore, which penetrate these strata to any depth, between the valleys, should furnish a copious supply of water, especially if the bore-hole strikes fissures or cavities in the water-bearing rock. The correctness of this statement seems to be, in a great measure, demonstrated by the deep wells of the region, a detailed description of which is as follows:—

THE CHICKAMAUGA PARK DEEP WELLS.—The largest number of deep wells, anywhere to be found in the Paleozoic area, occur in the Chickamauga National Park, in Catoosa county, only a short distance south of the Georgia-Tennessee line. These wells, which were constructed, chiefly to supply the emergency water-works system of the park during the mobilization of troops at that point, at the beginning of the Spanish-American war, in the sum-

mer of 1898, are between 20 and 30 in number. They vary, with one exception, from 90 to 160 feet in depth. They are pretty evenly distributed throughout the park, which covers an area of about ten square miles.

Generally speaking, the park is a plain, with a slightly undulating surface sloping gradually toward Chickamauga Creek, which forms part of the eastern boundary. West of the park, about one mile, is Missionary Ridge, which, in places, attains an elevation of 200 feet or more above the general level of the park. The surface-drainage east of the ridge is eastward toward Chickamauga Creek. The ridge, here referred to, is formed of Knox dolomite; it constitutes the western limb of a synclinal fold, within the trough of which, and forming the surface of the greater part of the park, is the Chickamauga limestone. With only one or two exceptions, all the deep drilled wells in the park commence in the Chickamauga limestone, and probably obtain their water-supply from the upper beds of the Knox dolomite. The latter formation, at that point, is a heavy-bedded magnesian limestone, often siliceous and frequently giving rise to limesinks. The Chickamauga limestone, on the other hand, is usually thinner bedded; and it often contains clay partings between the layers. The wells are all non-flowing, except the one located near Cloud Spring at the United States Army Post, in the extreme northern part of the park. This well is six inches in diameter and 310 feet deep; and it furnishes about 150,000 gallons daily. The water rises 12 feet above the surface. It is said to come from a cavity, two feet deep, near the bottom of the well. When the cavity was first penetrated by the drill, it is reported that leaves and small twigs were brought to the surface.

The character of the water from the Cloud well is shown by the following analysis by Mr. Edwin R. Hodge, Chemist in charge of the Chemical Laboratory, Surgeon General's Office, War Department, Washington, D. C., April 30th, 1903, furnished by Mr. E. E. Betts, Park Engineer: —

	Parts per Million
Chlorine	2.500
Nitrites	trace
Nitrates	trace
Free Ammonia	0.034
Albuminoid Ammonia	0.040
Oxygen Used	0.963
Total Solids	145.500
Loss on Ignition	39.500

The water was colorless, odorless, tasteless, and of a neutral reaction. It had no appreciable sediment; but it possessed a faintly opalescent cloudiness, when it reached the laboratory. There was no perceptible blackening or charring on incineration of the residue. Organically, the water is to be regarded as of the very first class. Coming through limestone, as may be suspected, the water is hard, but only moderately so, as is indicated by the following:—

Total Hardness	16.18 per gallon
Temporary Hardness	7.90 “ “
Permanent Hardness	8.28 “ “

The mineral constituents consist largely of carbonates of lime and magnesia, with small traces of the sulphates of these metals. There are also traces of iron and alumina.

With the exception of a few feet, the well penetrates Knox dolomite its entire depth. The other wells of the park, nearly all of which furnish a copious supply of water, are said to be but little affected by the seasons. The character of the water, in all the wells, appears to be about the same as the water from the Cloud well.

THE BAGWELL WELL.—This well, which was bored in 1901, is located at Mr. R. B. Bagwell's residence, near the southeast corner of Chickamauga Park, and about 200 yards from Chickamauga Creek. The well has a depth of 232 feet, and is said to penetrate hard rocks its entire depth, except the first 15 feet, which consist of clays. The greater part of this rock, judging from the location of the well, is Chickamauga limestone; however, it is more than likely that the well stops in the upper beds of the Knox dolomite. The



CRAWFISH SPRING, NEAR CHICKAMAUGA NATIONAL PARK, WALKER COUNTY, GEORGIA.



water, which is quite saline, is reported to come from within a few feet of the bottom of the well. It rises to within 70 or 80 feet of the surface. At the time of the writer's visit, the capacity of the well had never been tested, and nothing definite seemed to be known about the amount of water-supply.

The mineral constituents of the water from the Bagwell well are shown by the following analysis, made by Mr. J. M. McCandless, State Chemist:—

Specific Gravity at 60° F., 1.0520		Per Cent.
Sodium Chloride	5.4791	
Potassium Chloride	0.0335	
Lithium Sulphate	0.0225	
Magnesium Chloride	0.5265	
Calcium Sulphate	0.1883	
Calcium Chloride	0.4831	
Calcium Carbonate	0.0192	
Magnesium Bromide	0.0494	
Sodium Iodide	0.0023	
Iron Sesqui-oxide and Alumina.....	0.0053	
Silica	0.0045	
Water	93.1865	
Total	100.0002	

The mixed salts in this water, amounting to 6.8137 per cent., when reduced to a dry condition, have the following composition:—

Sodium Chloride	80.42
Potassium Chloride	0.49
Lithium Sulphate	0.33
Magnesium Chloride	7.73
Calcium Sulphate	2.76
Calcium Chloride	7.09
Calcium Carbonate	0.28
Magnesium Bromide	0.72
Sodium Iodide	0.03
Silica	0.07
Oxides of Iron and Alumina.....	0.08
Total	100.00

This water, it will be noticed, carries about twice as much sodium

chloride as common sea water, and a rather unusual amount of lithium, bromine and iodine. It is difficult to explain the occurrence of this remarkable well, as no water of similar nature is known at any other point in the Paleozoic area.

Besides the wells above described, there are also a number of other private deep wells in the vicinity of the park, but no detailed description of these wells was secured.

THE W. M. SCOTT WELL.—This well is located in the northwestern part of Gordon county near the eastern base of Horn Mountain, three and a half miles southwest of Sugar Valley. The well which was originally put down as a prospect hole in search for coal by Mr. W. M. Scott, of Atlanta, about 15 years ago, is two inches in diameter and 156 feet deep; and it flows, through a 1½-inch discharge pipe, two gallons of water per minute. This well, together with the well located near Cloud Spring in Chickamauga Park, are the only two deep flowing wells reported in the Paleozoic area.

The Scott well begins in the lower beds of the Fort Payne chert, and extends to the base of the Chattanooga black shale. As the water is reported to have been struck in fissures in the rock lying just below the black shale, it no doubt comes from the upper part of the Rockwood formation, which constitutes the upper division of the Silurian rocks of Georgia. Structurally considered, the well is situated on the eastern limb of an anticlinal fold, the rocks of which, at that point, have a steep dip eastward. The water has a rather strong iron taste, and forms about the overflow pipe a heavy yellowish precipitate of iron sesqui-hydrate. Locally, the water has quite a reputation as a mineral water.

An analysis of the water by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia, is as follows:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	20.20	1.178
Sulphur Trioxide	59.60	3.476
Carbon Dioxide	141.40	8.981
Phosphorus Pentoxide	trace	trace
Chlorine	5.60	.327
Iron Sesqui-oxide	1.80	.105

	Parts per Million	Grains per U. S. Gallon
Alumina	0.40	.023
Magnesia	21.60	1.260
Lime	68.30	3.983
Potash	3.50	.204
Soda	8.20	.478
<i>Probable Combinations</i>		
Potassium Chloride	5.55	.324
Sodium Chloride	4.88	.258
Sodium Sulphate	12.87	.751
Magnesium Sulphate	64.80	3.779
Aluminum Sulphate	1.34	.078
Calcium Sulphate	13.96	.814
Calcium Carbonate	111.70	6.514
Iron Carbonate	2.61	.152
Total Solids	237.91	13.848
Free Carbon Dioxide	91.26	5.322

THE ROME PETROLEUM & IRON COMPANY'S WELL, No. 1. — The Rome Petroleum & Iron Company's well No. 1 is located in Floyd county, about four and a half miles northwest of Rome. The well, which was put down in 1902 and 1903, has a total depth of about 1,200 feet. It is six inches in diameter, and is said to furnish ten gallons of hard water per minute. The water is reported to come from fissures in limestone at the following depths from the surface: 40, 180 and 960 feet, respectively. Below the 960-foot fissure, it is claimed that the well furnishes but little or no water. It is said that the water from the water-bearing fissures rose in the well, for some distance above the points at which it was struck; but, in no instance, was there a flow. This well was commenced in the lower division of the Carboniferous, known as the Floyd shale, and it was stopped apparently in the Rockwood formation, the upper member of the Silurian rocks.

THE ROME PETROLEUM & IRON COMPANY'S WELL, No. 2. — This well is situated in what is known as the flat-woods region about eight miles west of Rome. It also was put down in 1902 and 1903, in search for oil. It is six inches in diameter, and is reported to attain a depth of 1,850 feet. Water is said to have been struck in

fissures in the rock at 60, 240, 400 and 900 feet, respectively; but the water from none of the fissures rises nearer than to within two or three feet of the surface. The maximum water-supply of the well is reported to be ten gallons per minute. It is said to be a mineral water, but the character and amount of the mineral constituents were not ascertained. The geologic formations penetrated in this well are probably about the same as those penetrated in well No. 1.

THE STANDARD COTTON MILL WELL. — This well is located within the corporate limits of Cedartown, the county seat of Polk county. It was put down in 1902, for the purpose of supplying the cotton mill. The well is six inches in diameter and 96 feet deep; and it has furnished as much water as 3,200 gallons per hour, the capacity of pump. The water, which rises to within 16 feet of the surface, is reported to come from a fissure or cavity in the limestone near the bottom of the well. The strata encountered in sinking this well are said to be residual clays for 14 feet, followed by limestone with thin partings of shale. The residual clays, here referred to, are probably derived from the weathering of the Knox dolomite which forms a hill only a few hundred yards to the eastward. The underlying limestones, with their shale partings, seem to be the lower beds of the Chickamauga limestone, which, at this point, has a low dip to the west. One or two other deep wells were put down at Cedartown some years ago, in the western part of the town; but no definite information concerning these wells was obtainable.

THE ALLGOOD WELL. — Mr. H. C. Allgood's well is located near the Southern Railway depot at Rockmart, a small town in the eastern part of Polk county. The well is six inches in diameter and 167 feet deep; it furnishes about ten gallons of water a minute. The water, which is said to be hard, rises to within 27 feet of the surface; it is reported to come from small fissures in the limestone. With the exception of the first ten feet, which is clay, this well is said to penetrate limestone its entire depth. This limestone, which has been mapped by Hayes as belonging to the Chickamauga formation, in the vicinity of Rockmart, as shown by the surface exposures, is highly argillaceous; it is, therefore, as the wells attest,

not a very satisfactory water-bearing formation. In addition to the well here described, there are three other deep drilled wells within the corporate limits of Rockmart. These wells, which vary from 75 to 100 feet in depth, penetrate formations similar to those penetrated by the Allgood well, and they furnish about the same quantity of water.

THE SAND MOUNTAIN AND LOOKOUT MOUNTAIN WELLS. — Other deep borings, besides those above described, occur on Sand Mountain of Dade county. These bore holes, which were made in prospecting for coal, vary from 75 to 350 feet in depth. The holes, with but few exceptions, are said to have struck water in greater or less abundance. As they were put down, however, only for the purpose of locating coal seams, no effort was made, in any case, to ascertain the amount of the water-supply from the different water-bearing strata. Deep borings, of like character, have also been put down on Lookout Mountain in Walker county; but, likewise, no information was obtainable, concerning the extent and character of the different water-bearing strata penetrated. As these two mountains are formed largely of sandstone and conglomerate, interstratified with impervious shales, there seems to be no reason, why deep bore-holes, located near the center of these mountains, which are broad synclinal folds of carboniferous strata, should not furnish a copious supply of water. Such bore-holes, in places, no doubt might furnish flowing water; as, at many places, the brows of the mountains are from 50 to 100 feet higher than their central axes.

SHALLOW WELLS

Favorable conditions for successful shallow wells are general throughout the Paleozoic area. These wells, in nearly all cases, obtain their water-supply from the residual clays derived from the decay and disintegration of the underlying rocks. In some instances, the wells penetrate, for a short distance, the underlying limestones, sandstones or shales; but the great majority penetrate only the overlying clays, which may vary in thickness from 20 feet, or less, to a maximum of 90 feet. The clays differ greatly in mineral composition, as well as in physical structure. Those derived from cherty

limestones, as the Knox dolomite, or from sandstones, are highly siliceous and porous; while those derived from the shales contain a high percentage of alumina, and are in a large measure impervious to water. The wells penetrating the former clays almost invariably furnish a more copious supply of water than the latter. The wells which penetrate the more porous clays, however, are usually more or less affected by droughts; and, as a consequence, they are not always so reliable, during dry seasons, as the wells in the less porous clays.

The character of the water from these shallow wells may be soft or hard, depending largely upon the nature of the clays which they penetrate. When the clays are derived from limestone, and the calcium carbonate has not been thoroughly leached out, the waters are almost invariably hard; but, on the other hand, where the clays are derived from sandstones, argillaceous shales, or even from the highly siliceous layers of Knox dolomite, the waters are soft. In a few instances, where these wells obtain their water-supply from aluminous shales, as in the case of Mrs. Hughes' mineral well, located in Floyd county, two miles west of Rome, the waters contain an abnormal amount of mineral matter, as is shown by the following analysis made by Dr. Everhart, in the laboratory of the Geological Survey of Georgia:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	15.87	0.925
Sulphur Trioxide	227.90	13.290
Phosphorus Pentoxide	trace	trace
Carbon Dioxide	327.00	19.069
Chlorine	38.50	2.245
Iron Sesqui-oxide and Alumina.....	1.44	0.084
Magnesia	77.90	4.542
Lime	258.25	15.066
Potash	1.54	0.089
Soda	47.20	2.752
<i>Probable Combinations</i>		
Potassium Chloride	2.44	0.142
Sodium Chloride	61.53	3.588
Sodium Sulphate	33.41	1.948

	Parts per Million	Grains per U. S. Gallon
Calcium Sulphate	80.59	4.699
Calcium Carbonate	394.55	23.008
Magnesium Sulphate	233.70	13.628
Total Solids	823.53	48.025
Free Carbon Dioxide	153.40	8.946

The shallow wells, which are the chief source of supply of drinking water in the rural districts, as well as in the small towns in the Paleozoic area, have an average depth of about 30 feet. These wells, in most cases, require no curbing; and, as a consequence, they can be put down at small cost. This accounts, no doubt, in a great measure, for the general use of shallow wells throughout the region.

SPRINGS

The Paleozoic, like the Crystalline area, is noted for its numerous springs. They are of frequent occurrence in nearly all the valleys throughout the region. In many instances, the springs are of large size; but the great majority are small, furnishing only a few hundred gallons per hour. The distribution of the larger springs, as shown by their location, is governed by certain geologic conditions. These conditions, which have been referred to elsewhere in this report, are the folded and faulted condition of the formations, together with a succession of more or less porous and fissured limestones with compact and impervious shales. In locating the larger springs on a geologic map, it will be found that they are nearly always situated near the contact of the Knox dolomite with some more impervious limestone, or shale. When these conditions are wanting, the springs are found along fault-lines. One of the most favorable positions for the occurrence of large springs seems to be at the contact of the Knox dolomite and the Chickamauga limestone, or at the contact of the former with the Connasauga shale. The smaller springs, on the other hand, seem to be confined to no special geological horizon and they are likely to occur at almost any point along the valleys where the rocks come to the surface.

Common Springs.

The springs of the Paleozoic area, like those of the other divisions of the State, consist of common springs and mineral springs. A few of the largest and most important of the common springs, which have been visited by the writer are here described in detail.

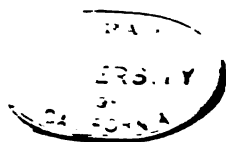
CRAWFISH SPRING.—Crawfish Spring, which furnishes about 14,000,000 gallons of water per day is the largest spring in the Paleozoic area. The spring is located in the northern part of Walker county, about two miles southeast of Chickamauga Park, and within a few hundred yards of Chickamauga station, a small town on the Central of Georgia Railway. The water, as it flows from the base of a small dolomite hill, forms a beautiful stream several rods wide and from two to five feet deep. This stream, which joins Chickamauga Creek about half-a-mile away, contains several other large springs, which, in the aggregate, are said to furnish an amount of water equal in volume to Crawfish Spring.

The geological position of Crawfish Spring is near the contact of the Chickamauga limestone and the Knox dolomite. The latter formation forms a very prominent chert ridge, known as Missionary Ridge, a short distance to the west, which appears to be the catchment area that supplies the springs. The only improvement in the immediate vicinity of the spring is a large, well-constructed hotel, which, during the mobilization of the troops at Chickamauga Park, at the beginning of the Spanish-American war, was used as a hospital. There seems to have been an effort made, some years ago, to establish a summer resort at Crawfish Spring; but the undertaking appears to have been unsuccessful. An effort was made, at one time, to utilize the spring for power purposes; but that project likewise seems to have been unprofitable.

The character of the water from Crawfish Spring is shown by the following analysis, furnished by Hon. Gordon Lee, the owner of the spring :—



VIEW OF A STREAM FORMED BY CRAWFISH SPRING, WALKER COUNTY, GEORGIA.



UNDERGROUND WATERS OF THE PALEOZOIC AREA 265

<i>Constituents Determined</i>	<i>Grains per U. S. Gallon</i>
Bicarbonate of Lime	6.7530
Bicarbonate of Magnesia	4.5440
Sodium Chloride	0.8560
Potassium Chloride	0.0480
Silica	0.0537
Free Ammonia	0.0029
Albuminoid Ammonia	0.0025
Oxygen Absorbed	0.0310
Total Solids	12.7742

DEW'S MILL SPRING. — This spring is located in Gordon county about eight miles east of Calhoun, the county seat. It is a very large spring, furnishing, according to Mr. B. M. Hall, Consulting Engineer, U. S. Geological Survey, 7,200 gallons of water per minute. The spring flows from a large cavernous opening at the base of a bluff, near the contact of the Knox dolomite and the underlying Connasauga shale. The water from the spring forms a good sized stream, which operates a flour mill, located only a short distance from the spring. The flowage of the spring is said to be but little affected by the seasons. The water is hard, and nearly always transparent. The catchment area of the spring seems to be the dry, cherty Knox dolomite ridges lying to the west.

THE LUKENS SPRING. — This spring, which is owned by Mrs. Olive A. Lukens of Atlanta, is located in Whitfield county, about one mile south of Dalton. The capacity of the spring, according to Mrs. Lukens, is 1,500,000 gallons a day. It is said to be unaffected by droughts, and never becomes muddy after hard rains. The water is hard and transparent, and no precipitate results on standing. There escapes with the water, at irregular intervals, bubbles which seem to consist of air. The spring emerges at the base of a hill near the line of contact of the Chickamauga limestone with the Knox dolomite. The Lukens Spring at present is used only to supply a fish pond near by, and a small farm house located on the hill just above the spring.

THE HAMILTON SPRING. — The Hamilton Spring, which is owned by the Crown Cotton Mills, is located within the corporate

limits of Dalton. The spring is said to furnish about 10,000,000 gallons a day. The water, which is hard, is used to supply the Crown Cotton Mills and the city of Dalton. The spring is located near the contact of the Chickamauga limestone with the Knox dolomite. The flow of the spring is reported to be affected by long droughts, but the water never becomes muddy after heavy rains.

HUSTON SPRING. — Huston Spring is in the southwestern part of Whitfield county about one and a half miles north of Carbondale and within a few hundred yards of the Southern Railway. The spring emerges from a sag at the base of one of the foot-hills of Chattoogata Mountain, near the contact of the Connausauga shale (Cambrian) and the Floyd shale (Carboniferous), which are here brought into juxtaposition by a fault representing a displacement of several hundred feet. The flow of the Huston spring is 2,100 gallons a minute. It is said to be unaffected by droughts, and never becomes muddy after rains. The water is hard and, according to Mr. Sidney Cooledge, of Boston, Mass., contains 36.80 grains of calcium carbonate per gallon. Originally the water from this spring was utilized in operating a small mill, but, at present, it is used only for domestic purposes.

McFARLAND SPRING. — This spring is located within the corporate limits of Rossville in the extreme northeastern corner of Whitfield county. It gushes from a cavern in the hillside as a bold spring near the line of contact of the Knox dolomite and the Chickamauga limestone. The water, which is hard, is used for general domestic purposes; it also supplies a small fish pond.

BLOWING SPRING. — Blowing Spring, so called on account of a current of air alternately passing in and out at the cave-like opening from which the water flows, is situated near the Chattanooga Southern Railroad in Walker county, about two and a half miles north of Flintstone, and within a few hundred yards of the Georgia-Tennessee line. This spring, which furnishes several gallons of hard water a minute, flows from the Bangor limestone. The water is used only for domestic purposes.¹

CAVE SPRING. — This spring is located in the southern part of

¹ For an explanation of the wind currents of this spring see pp. 295-301.

Floyd county, within the corporate limits of the village of Cave Spring. It emerges from the base of a Knox dolomite hill, near the line of contact of the Connasauga shale and the Knox dolomite. On the hill-slope just above the spring, is a cave which extends down to the underground stream which supplies the spring. This spring is much used by the residents of the town for general domestic purposes; and it also supplies the Georgia Deaf and Dumb Asylum, located near by. The water is hard and clear, never becoming turbid after rains. The flow of this spring, measured by the U. S. Geological Survey in 1904, is 3,444,868 gallons in 24 hours.

In addition to this spring, there are several other springs within the corporate limits of Cave Spring, none of them, however, being as large as the one above described. The catchment area of these springs appears to be the dry, cherty Knox dolomite ridges lying a short distance to the east of the town.

CEDARTOWN SPRING. — This is a very large limestone spring at Cedartown, the county-seat of Polk county. The capacity of the spring is said to be about 2,500,000 gallons a day. It emerges as a large stream from cavities in the limestone rock, at the base of a small hill near the center of the town. This spring, which furnishes the town with water, is surrounded by a substantial wall of masonry. This wall, in addition to its protecting the spring from surface drainage, is also used as a part of the foundation of the power house of the pumping station, which forces the water to the stand-pipe located on a hill in another part of the town.

Some anxiety has been expressed, from time to time, as to the possible surface contamination of the Cedartown Spring. It has been thought by some, as the spring becomes muddy after rains, that a certain lime-sink in the neighborhood has connection with the subterranean stream which supplies the spring. This supposition seems never to have been conclusively demonstrated; but the writer has been informed that the town authorities have taken steps to guard against any contamination from this source.

Besides the spring here described, there are three or four other springs in the neighborhood of Cedartown which furnish from 500,000 to 2,000,000 gallons a day. These springs all have the same

general character as the Cedartown Spring, and they flow from the Chickamauga limestone near its contact with the Knox dolomite.

ARAGON SPRING. — This spring is located at the Aragon Mills, in the northeast part of Polk county near the contact of the Chickamauga limestone and the Knox dolomite. It emerges as a bold stream from the base of a small rocky hill, only a few hundred yards from the Aragon Cotton Mills, which it supplies with water. The spring is said to be unaffected by either rain or droughts. Its daily capacity is 1,800,000 gallons. The water is always clear and colorless, and has a temperature of 62° F.

The mineral constituents of the water are shown by the following analysis furnished by Mr. T. C. Wolcott, Treasurer of the Aragon Cotton Mills: —

	Parts per Million
Total Solids	219.4
Organic and Vegetable Matter.....	95.7
Calcium Carbonate	80.8
Magnesium Carbonate	42.9
Sulphates	trace

Near the spring here described, is another spring, owned by the Aragon Cotton Mills, with a daily flow of 1,760,000 gallons. The mineral constituents of the water are said to be practically the same as those from the spring which supplies the Aragon mill. There are three other limestone springs within a mile, or less, of Aragon. One of these springs, known as Randall spring, located on the bank of Euharlee Creek, has a capacity of 500,000 gallons per day. The other two springs are said to each furnish about twice as much water as the Randall spring. The catchment area of this group of springs is apparently the Knox dolomite ridges west of Aragon.

BIG SPRING. — This spring is located near the Central of Georgia Railroad, about one mile north of Lafayette, the county seat of Walker county. It supplies water to the Union Cotton Mills, located near by. The water is hard and transparent. The capacity of the spring is several thousand gallons per day. The spring is near the contact of the Knox dolomite and the Connasauga shale.

KERR'S SPRING. — Kerr's Spring is in the northeastern part of Bartow county, about half-a-mile west of Hall's station. The spring is large, and it furnishes probably a million gallons of water a day. The water is clear and odorless, and it forms no precipitate on standing. There escapes with the water many bubbles, probably air. The spring emerges from the lower layers of the Knox dolomite near its contact with the Connasauga shale. Other springs, similar to the Kerr spring, occur at Barnesley and near Cement. These springs likewise emerge from near the line of contact of the Knox dolomite and the Connasauga shale.

CLEGHORN SPRING. — This spring, which is said to have a daily capacity of more than a million gallons, is within the corporate limits of Summerville, the county seat of Chattooga county. It emerges as a stream from crevices in the Knox dolomite near its contact with the Connasauga shale. The flow of the spring is said to be quite uniform throughout the year. The water, which is hard and always clear, is used only for drinking purposes. The catchment area of the Cleghorn Spring appears to be the cherty Knox dolomite ridges lying immediately west of Summerville.

PHŒNIX SPRING. — This spring, which is owned by the Phœnix Iron and Coal Company, is situated on the west slope of Lookout Mountain, in Dade county, about five miles north of Rising Fawn. It emerges as a bold stream from the fissures in the Bangor limestone. The water is clear, and it deposits a heavy precipitate of calcium carbonate. This deposit, which is a porous, rather soft material, forms a layer several inches in thickness in the bed of the branch flowing from the spring. The spring is somewhat inaccessible, owing to the steepness of the mountain slope on which it is situated, and, as a consequence, it is seldom visited.

KENSINGTON SPRING. — This spring is within the corporate limits of Kensington, a small town on the Chattanooga Southern Railroad, in the western part of Walker county. It is a bold spring, issuing from crevices in the limestone rock at the base of a hill near the contact of the Knox dolomite with the Chickamauga limestone. The spring furnishes several hundred thousand gallons of water per

day. The water is hard, and is used for drinking and general domestic purposes.

ROUNSAVILLE SPRING. — The Rounsaville Spring is located in the southeastern part of Floyd county, at Chambers on the Southern Railway, about seven miles south of Rome. This spring, according to Mr. J. N. Cheney, furnishes 800 cubic feet of water a minute, which is utilized in operating a flour mill. The water, which is hard and always clear, is said to be but little affected by the seasons. The spring emerges as a bold stream from limestone rocks, at the base of the bluff of Knox dolomite, and appears to be near the southern terminus of one of the parallel faults occurring in the vicinity of Rome.

LINDALE SPRINGS. — The Lindale Springs, which are located at the thriving town of Lindale, four miles south of Rome, are large limestone springs, furnishing about 800 gallons a minute. The character of the water, which is used chiefly for supplying the town of Lindale, is shown by the following analysis, obtained in answer to a circular letter addressed to the Mayor: —

ANALYSIS OF WATER FROM SPRING NO. 1

	Parts per Million
Free Ammonia .....	.0004
Albuminoid Ammonia .....	.0094
Chlorine .....	.1200
Nitrogen as Nitrites .....	.0040
Nitrogen as Nitrates	none
Hardness	11.0500

ANALYSIS OF WATER FROM SPRING NO. 2

	Parts Per Million
Total Solids	15.900
Volatile Organic Matter	3.000
Fixed Solids	12.900
Free Ammonia .....	.008
Albuminoid Ammonia .....	.007
Chlorine	2.300
Hardness	11.800

In addition to the springs above described, there are a large number of other common springs of considerable size in the Paleozoic area.

MINERAL SPRINGS

There are a number of mineral springs in the Paleozoic area, several of which have considerable local reputation. These springs are small, and are confined mainly to the argillaceous limestones and the carboniferous shales of the region. Some of the most important of these springs are here described.

CATOOSA SPRINGS. — This group of springs is located in the eastern part of Catoosa county, four miles east of Ringgold. They have long been known as a popular summer resort. The springs, 12 in number, are situated within a basin-like depression, covering an area of less than two acres. Surrounding the basin, the surface is broken and hilly. Some of the near-by hills in the vicinity attain an elevation of 400 feet above the spring basin, which, according to the U. S. topographic map of the region, is between 700 and 800 feet above sea-level. In the immediate vicinity of the springs, on gradually sloping ground, are situated a number of cottages and the site of a large hotel, which was destroyed by fire a few years ago. Previous to the destruction of the hotel, it is claimed that this resort, which has in the last few years become almost abandoned, could entertain, at one time, as many as 600 guests.

The Catoosa Springs are all small, none of them furnishing more than a few gallons of water per minute. They issue as minute streams from fissures and crevices in beds of shale interlaminated with carbonaceous, cherty limestone of Cambrian age. A general idea may be had of the character of the water of the Catoosa Springs, from the following analyses made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia: —

CONSTITUENTS DETERMINED.	Parts per Million.				Grains per U. S. Gallon.			
	1	2	3	4	1	2	3	4
Silica.....	18.15	31.00	70.00	16.75	1.058	1.808	4.082	.977
Sulphur Trioxide...	632.66	608.00	762.40	700.43	36.895	35.457	44.462	40.848
Carbon Dioxide.....	122.70	138.28	181.40	125.87	7.156	8.064	10.579	7.340
Phosphorus Pent-oxide.....	trace	trace	.....	.....	trace	trace	.....	.....
Chlorine.....	7.00	5.60	4.90	4.90	.408	.327	.286	.286
Iron Sesqui-oxide...	2.91	3.00	3.40	.60	.170	.175	.198	.035
Alumina.....	.22	1.00	1.00	.68	.013	.058	.058	.035
Lime.....	412.00	424.80	482.40	408.25	24.027	24.773	28.133	23.809
Magnesia.....	63.30	80.28	93.68	60.00	3.692	4.682	5.463	3.499
Potash.....	5.90	11.27	7.57	3.02	.344	.657	.441	.177
Soda.....	4.02	15.90	16.96	8.00	.234	.927	.989	.467
PROBABLE COMBINATIONS.								
Potassium Chloride.....	9.33	11.75	10.14	4.78	.544	.685	.591	.279
Potassium Sulphate.....	.....	7.14	2.00	.....	.....	.416	.117	.....
Sodium Chloride.....	3.52	.....	.....	4.32	.205	.....	.....	.252
Sodium Sulphate.....	4.30	36.41	42.07	13.08	.251	2.123	2.453	.763
Sodium Phosphate.....	trace	trace	.....	.....	trace	trace	.....	.....
Magnesium Sulphate.....	189.90	240.84	281.04	180.00	11.075	14.045	16.390	10.497
Calcium Sulphate.....	847.89	711.11	923.54	970.70	49.447	41.471	53.859	56.609
Calcium Carbonate.....	112.26	212.98	182.36	15.27	6.547	12.421	10.635	.890
Aluminum Sulphate.....	3.79	3.35	3.35	1.98	.221	.195	.195	.115
Iron Carbonate.....	4.22	4.35	6.46	1.14	.246	.254	.377	.067
Total Solids.....	1,193.36	1,224.36	1,520.96	1,208.02	69.594	93.418	88.699	70.449
Free Carbon Dioxide.....	73.31	44.58	101.16	58.69	4.275	2.600	5.899	3.422

1 Epsom Spring.

3 Buffalo Lithia Spring.

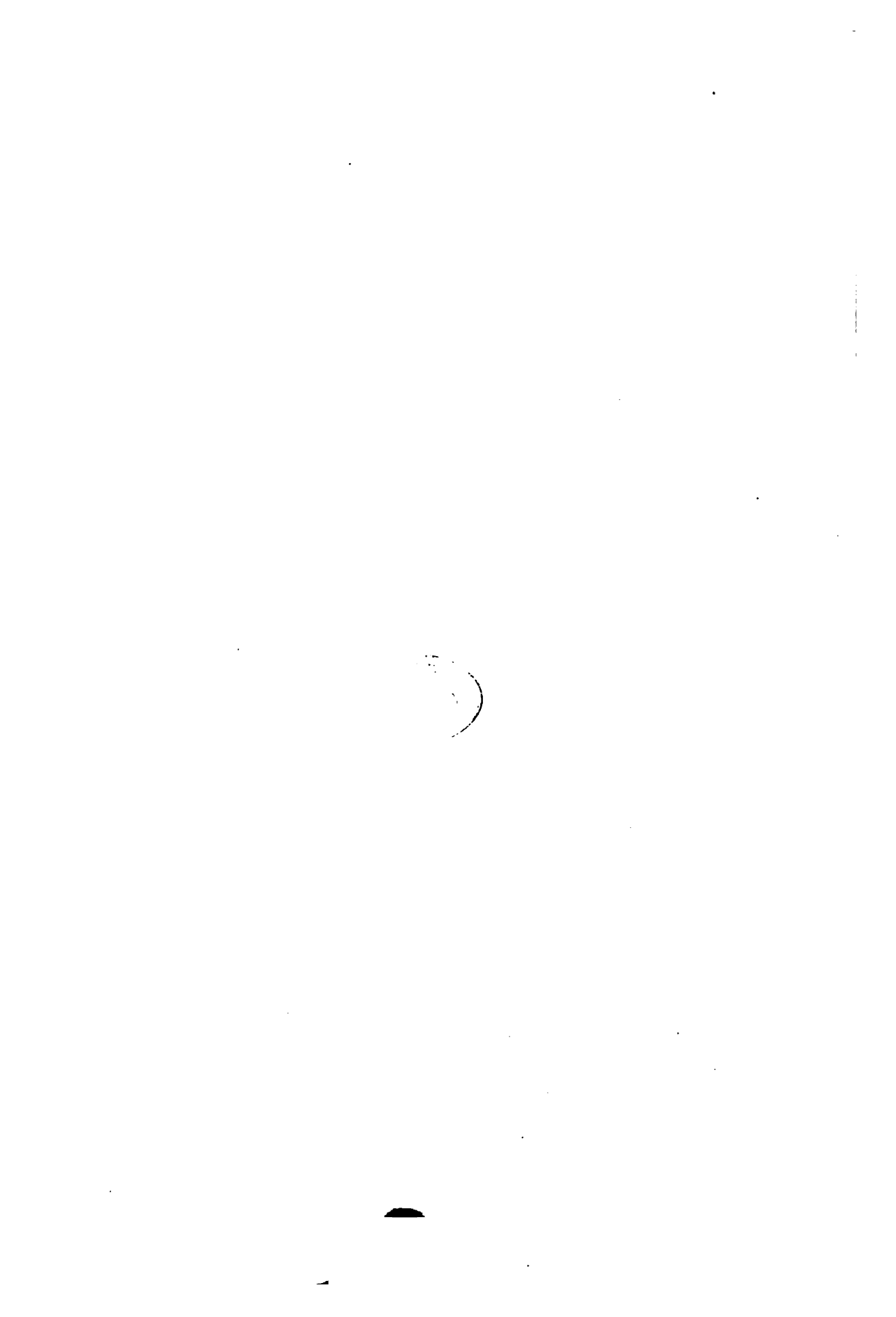
2 Coffee Spring.

4 Cosmetic Spring.

CHEROKEE SPRING. — This is a bold chalybeate spring, located in a small valley at the western base of White Oak Mountain, about two miles east of Ringgold. This spring is said to have been much frequented some years ago by health seekers, but it is now only occasionally visited. There are no improvements near the spring, except a farm-house. The water, which yields quite a copious precipitate of iron sesqui-oxide, flows from a small fissure in the dark



VIEW SHOWING HOW SALT WAS INTRODUCED IN THE WELL, DURING THE QUITMAN EXPERIMENT.



aluminous rock, only a few feet below an outcropping of the Devonian black shale.

An analysis of the water by Dr. Edgar Everhart, in the laboratory of the Geological Survey of Georgia, is as follows:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	19.30	1.125
Sulphur Trioxide	16.60	.937
Carbon Dioxide	123.80	7.220
Phosphorus Pentoxide	trace	trace
Chlorine	4.90	.286
Iron Sesqui-oxide	15.20	.886
Alumina	1.20	.070
Lime	61.20	3.569
Magnesia	3.60	.210
Potash	3.40	.198
Soda	5.60	.327
<i>Probable Combinations</i>		
Potassium Chloride	5.40	.315
Sodium Chloride	3.84	.224
Sodium Sulphate	8.18	.477
Magnesium Sulphate	10.80	.630
Calcium Sulphate	3.35	.195
Calcium Carbonate	109.29	6.374
Aluminum Sulphate	4.02	.234
Iron Carbonate	22.04	1.285
Total Solids	186.22	10.859
Free Carbon Dioxide	67.73	3.950

GORDON SPRING. — Prior to the Civil War, Gordon Spring was a very popular summer resort; but since then, it has been allowed to decline. The buildings, with the exception of one or two smaller ones, have all been burned or otherwise destroyed, so that there are at present practically no facilities whatever for the accommodation of guests. The spring is located at the eastern base of Taylor's Ridge, in the western part of Whitfield county, about twelve miles west of Dalton. It is a small chalybeate spring, furnishing about three gallons of water per minute. The water is clear, but on standing, throws down a precipitate of iron sesqui-oxide. In addition

to the main spring, from which the sample of water was secured for analysis, there are several other smaller springs near by, which are also said to possess medicinal properties. These springs are all located in a small depression, or basin, at the foot of Taylor's Ridge, near the line of contact of the Carboniferous shales and the Silurian sandstone. Gordon Spring is well located for a summer resort, but, unfortunately, it is too far from the railroad to attract visitors.

The mineral constituents of the water are shown by the following analysis made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	15.50	.904
Sulphur Trioxide	14.78	.862
Carbon Dioxide	182.40	10.637
Phosphorus Pentoxide	trace	trace
Chlorine	5.60	.327
Iron Sesqui-oxide	5.40	.315
Alumina	0.40	.023
Manganese	trace	trace
Lime ..	82.00	4.782
Magnesia	12.76	.744
Potash	2.80	.163
Soda	10.60	.618
<i>Probable Combinations</i>		
Potassium Chloride	4.44	.259
Sodium Chloride	5.75	.335
Sodium Sulphate	17.31	1.033
Sodium Phosphate	trace	trace
Magnesium Sulphate	7.55	.440
Magnesium Carbonate	21.50	1.254
Calcium Carbonate	146.43	8.540
Aluminum Sulphate	1.35	.079
Iron Carbonate	7.83	.457
Manganese Carbonate	trace	trace
Total Solids	227.66	13.301
Free Carbon Dioxide	103.75	6.050

MARTIN'S MINERAL SPRING. — This spring, owned by Mr. W. C. Martin, is located among the foot-hills of Chattooga Mountain,

about two miles southwest of Dalton. It is a small chalybeate spring, furnishing only 30 gallons of water an hour. The water, which has the distinct taste peculiar to compounds of iron, issues from the Devonian black shale. There are no improvements whatever in the immediate vicinity of the spring. However, it is much visited during the summer months by the people of Dalton, who seem to have great faith in the curative properties of the water.

An analysis of the water made in the laboratory of the Geological Survey of Georgia, by Dr. Edgar Everhart, is as follows: —

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	28.50	1.662
Sulphur Trioxide	17.92	1.045
Carbon Dioxide	63.20	3.686
Phosphorus Pentoxide	trace	trace
Chlorine	5.10	.297
Iron Sesqui-oxide	10.30	.601
Alumina	1.00	.058
Magnesia	12.61	.735
Lime	21.40	1.248
Manganese	trace	trace
Potash	4.00	.233
Soda	8.66	.505
<i>Probable Combinations</i>		
Potassium Chloride	6.23	.363
Sodium Chloride	3.46	.202
Sodium Sulphate	15.64	.912
Sodium Phosphate	trace	trace
Magnesium Sulphate	10.11	.584
Magnesium Carbonate	19.40	1.131
Calcium Carbonate	38.21	2.228
Aluminum Sulphate	3.35	.195
Iron Carbonate	14.94	.871
Manganese Carbonate	trace	trace
Total Solids	139.84	8.148
Free Carbon Dioxide	31.00	1.808

TRENTON MINERAL SPRING. — The Trenton Mineral Spring is located within the corporate limits of Trenton, the county seat of

Dade county. It is a small sulphur spring, furnishing only 30 gallons of water an hour. The water is clear, but it forms a white precipitate about the overflow pipe, and has a distinct odor of hydrogen sulphide. The water is much used in Trenton for drinking purposes. The spring issues as a minute stream from a small fissure in the Chicamauga limestone.

An analysis of the water by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia, is as follows:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	17.8c	1.038
Sulphur Trioxide	10.20	.595
Carbon Dioxide	297.00	17.320
Phosphorus Pentoxide	0.30	.017
Chlorine	12.25	.714
Iron Sesqui-oxide	5.40	.315
Alumina	2.35	.137
Magnesia	41.9c	2.444
Lithia	trace	trace
Lime	84.90	4.951
Potash	5.20	.303
Soda	38.00	2.216
<i>Probable Combinations</i>		
Potassium Chloride	8.24	.481
Lithium Chloride	trace	trace
Sodium Chloride	13.71	.800
Sodium Phosphate	0.60	.035
Sodium Sulphate	18.10	1.056
Sodium Carbonate	38.58	2.250
Magnesium Carbonate	87.99	5.131
Calcium Carbonate	151.61	8.842
Aluminum Sulphate	9.40	.548
Manganese Carbonate	trace	trace
Iron Carbonate	7.82	.457
Total Solids	353.85	20.627
Free Carbon Dioxide	165.10	9.628

MAJOR MINERAL SPRING. — This spring is located in the western part of Chattooga county, near the corporate limits of Menlo. It is

a small chalybeate spring, furnishing one gallon of water a minute. The water, which deposits quite a precipitate of iron oxide, has an astringent taste. The spring issues as a small stream from fissures in the Devonian black shale. The improvements consist of a poorly constructed boarding-house located on the hill just above the spring. Locally, Major Spring has quite a reputation, and is much visited during the summer by people from Chattooga and the surrounding counties.

The following is an analysis of the water made by Dr. Edgar Everhart in the laboratory of the Geological Survey of Georgia:—

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	65.30	3.808
Sulphur Trioxide	137.00	7.990
Carbon Dioxide	77.90	4.543
Phosphorus Pentoxide	trace	trace
Chlorine	5.60	.327
Iron Sesqui-oxide	49.50	2.304
Alumina	40.50	2.362
Manganous Oxide	1.40	.082
Lime	13.30	.776
Magnesia	6.00	.350
Potash .....	.92	.053
Soda	11.60	.676
<i>Probable Combinations</i>		
Potassium Chloride	1.46	.085
Sodium Chloride	7.35	.429
Sodium Sulphate	17.63	1.028
Sodium Phosphate	trace	trace
Magnesium Sulphate	18.00	1.050
Calcium Sulphate	32.30	1.884
Iron Sulphate	1.40	.082
Manganese Carbonate	3.00	.175
Aluminum Sulphate	135.80	7.920
Iron Carbonate	66.28	3.282
Total Solids	338.52	19.744
Free Carbon Dioxide	51.36	2.995

COHUTTA SPRINGS. — Cohutta Springs, a summer resort of local importance, is in the northern part of Murray county, at the base of one of the spur ridges of Cohutta Mountain, about 18 miles northeast of Spring Place. The spring, from which the resort takes its name, was known to the early settlers of Murray county; but it seemed not to have attracted attention until about 50 years ago, when the first log cabin was built near the spring. Since that time it has been much visited in the summer months by the people from Dalton and the surrounding country, who have constructed small cottages in the vicinity of the spring, for the accommodation of their families. These cottages, together with one or two small boarding-houses near by, are all the improvements about the spring. The location of Cohutta Springs is surpassed by but few summer resorts in the State, from a scenic point of view. It is within less than three miles of Grassy Mountain, which has an altitude of nearly 4,000 feet above sea-level; and it is only a short distance from some picturesque gorges and beautiful water-falls.

The spring furnishes only three gallons of water per minute. The water, which throws down a rather copious precipitate of iron oxide, issues from a small fissure in the dark pyritiferous Cambrian shales.

An analysis of the water from the spring, by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia, is as follows: —

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	15.00	.875
Sulphur Trioxide	6.53	.381
Carbon Dioxide	28.00	1.633
Chlorine	7.00	.408
Iron Sesqui-oxide	10.44	.609
Alumina	1.25	.073
Lime	5.81	.339
Magnesia	3.20	.187
Potash	2.05	.120
Soda	7.09	.413
<i>Probable Combinations</i>		
Potassium Chloride	3.25	.190
Sodium Chloride	8.98	.524
Sodium Sulphate	5.34	.311
Magnesium Sulphate	0.87	.051

	Parts per Million	Grains per U. S. Gallon
Magnesium Carbonate	6.11	.356
Calcium Carbonate	10.37	.605
Aluminum Sulphate	4.19	.244
Iron Carbonate	15.14	.883
Total Solids	69.25	4.039
Free Carbon Dioxide	14.51	.846

HAMPTON SPRING. — This spring is located along the edge of a deep, narrow hollow or gorge, about one mile east of Cohutta Spring. The spring is a small chalybeate spring flowing less than two gallons of water per minute. The only improvements near the spring are a few ill-constructed cottages, owned by individuals, who move their families to the spring for a short time during the hot summer months.

The character of the water is shown by the following analysis, made by Dr. Edgar Everhart, in the laboratory of the Geological Survey of Georgia: —

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	12.75	.744
Sulphur Trioxide	6.12	.357
Carbon Dioxide	24.40	1.423
Chlorine	6.30	.367
Iron Sesqui-oxide	9.66	.563
Alumina	1.45	.085
Lime	4.50	.262
Magnesia	2.61	.152
Potash	1.55	.090
Soda	5.08	.296
<i>Probable Combinations</i>		
Potassium Chloride	2.44	.142
Sodium Chloride	8.45	.493
Sodium Sulphate	1.39	.081
Magnesium Sulphate	3.15	.184
Magnesium Carbonate	3.27	.191
Calcium Carbonate	8.03	.468
Aluminum Sulphate	4.86	.283
Iron Carbonate	14.00	.816
Total Solids	58.34	3.442
Free Carbon Dioxide	13.85	.808

EVERETT SPRING. — Everett Spring is in the extreme northern part of Floyd county, about six miles west of Reeves, a small station on the Southern Railway. It is located in a narrow, picturesque valley between Horn and John Mountains, near the highway leading from Armuchee Valley to Rome. The spring is of local reputation only, and has no improvements near, except a farm-house and a small country store. The water emerges as a stream from the Carboniferous shale. The flow, which is said to be but little affected by the seasons, is less than one gallon a minute.

An analysis of the water, made by Dr. Edgar Everhart, in the laboratory of the Geological Survey of Georgia, is as follows: —

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	20.50	1.196
Sulphur Trioxide	8.86	.517
Carbon Dioxide	131.00	7.640
Phosphorus Pentoxide	trace	trace
Arsenic	trace	trace
Chlorine	10.20	.595
Iron Sesqui-oxide	7.20	.420
Alumina	3.40	.198
Lime	90.40	5.272
Magnesia	12.20	.711
Potash	2.83	.165
Manganese	trace	trace
Soda	11.82	.689
<i>Probable Combinations</i>		
Potassium Chloride	4.48	.261
Sodium Chloride	13.28	.780
Sodium Phosphate	trace	trace
Sodium Arsenite	trace	trace
Sodium Sulphate	1.52	.089
Sodium Carbonate	7.04	.411
Magnesium Carbonate	25.62	1.494
Calcium Carbonate	161.03	9.311
Aluminum Sulphate	11.40	.663
Iron Carbonate	10.44	.609
Manganese Carbonate	trace	trace
Total Solids.....	255.31	14.889
Free Carbon Dioxide	39.67	2.314



EXPOSURE OF MIOCENE MARLS AND CLAYS, PORTER'S LANDING, EFFINGHAM COUNTY, GEORGIA.



ROLAND SPRINGS. — These springs, which have long been known as a summer resort, are situated in a broken, hilly country in Bartow county, six miles northeast of Cartersville. Prior to the Civil War, Roland Springs was one of the most important resorts in the State. White, in his Statistics of Georgia published in 1849, in speaking of these springs, says: — "Roland Springs are too well known to need a particular description. They are becoming every season the center of fashion. Multitudes from every part of the State resort here, to partake of the excellent water as well as the liberal fare of the worthy proprietor."

In recent years, this resort has lost its former popularity. The buildings, which were said to have accommodated at one time as many as 600 guests, have all been destroyed, with the exception of one or two, which are now badly in need of repair. The resort is at present only occasionally visited. The people from Bartow and the surrounding counties now rarely frequent the springs. There are two main springs, each furnishing about the same quantity and quality of water. They are both rather bold chalybeate springs, issuing from fissures in a coarse granite, which seems to be an intrusive mass penetrating the Cambrian quartzites. The water has the peculiar taste of iron compounds; and, upon standing, it yields a rather copious precipitate of iron hydrate.

The following analysis by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia, was made from a sample of the water taken from the stone-curbed spring, a short distance north of the building; —

<i>Constituents Determined</i>	Parts per Million	Grains per U. S. Gallon
Silica	41.50	2.420
Sulphur Trioxide	6.80	.397
Carbon Dioxide	138.60	8.093
Phosphorus Pentoxide	trace	trace
Chlorine	4.76	.278
Iron Sesqui-oxide	5.40	.315
Alumina	0.50	.029
Lime	26.20	1.528
Magnesia	5.91	.345

	Parts per Million	Grains per U. S. Gallon
Manganous Oxide	0.20	.012
Potash	3.52	.205
Soda	15.90	.927
<i>Probable Combinations</i>		
Potassium Chloride	5.58	.325
Sodium Chloride	3.46	.196
Sodium Phosphate	trace	trace
Sodium Sulphate	9.99	.583
Sodium Carbonate	16.60	.968
Magnesium Carbonate	12.41	.724
Calcium Carbonate	46.80	2.739
Aluminum Sulphate	1.67	.097
Manganese Carbonate	0.32	.019
Iron Carbonate	7.83	.457
Total Solids	146.16	8.528
Free Carbon Dioxide	101.52	5.920

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CHAPTER XII

EXPERIMENT RELATING TO PROBLEMS OF WELL CONTAMINATION AT QUITMAN, GA.¹

INTRODUCTION

During the summer of 1903, a boring for a deep well, constructed by the town of Quitman, Ga., to improve its water-supply, penetrated, at a depth of 123 feet from the surface, in limestone, what appeared to be a cavity $6\frac{3}{4}$ feet deep. Immediately after the cavity had been penetrated by the drill the water rose to within 77 feet of the surface, at which point it remained. In extending the bore hole beyond this depth it was found that all of the water forced into the well to carry out the drillings, and also the drillings themselves, appeared to pass off by the cavity. It was further discovered that any quantity of water, however great, that was forced into the bore hole, did not raise the level of the water in the well above 77 feet, and, on the other hand, that continuous pumping was equally ineffective in lowering the level.

After the sinking of the well to a second water-bearing stratum, at a depth of 321 feet, another well was constructed with a view of testing more fully the water-carrying capacity of the underground cavity, which was supposed to be a channel of a large subterranean stream. The second well, 6 inches in diameter, was put down a few hundred yards southwest of the first well, and only a few feet from the margin of Russell Pond, a small body of stagnant water occupy-

¹ This paper was first published by the U. S. Geological Survey in water-supply and irrigation paper No. 110, 1905.

ing a nearly circular depression having the appearance of a partially filled lime sink. This well having been extended to the cavernous limestone, a canal was dug to connect it with the pond, and the water was allowed to flow from the pond into the well. The pond, which contained about one-half million gallons of water, was drained by the well in a few hours, without apparently affecting the level of the water in the bore hole, which remained constant at 77 feet from the surface. This test was conclusive to the town authorities that the underground cavity had a capacity to carry off an illimitable amount of water, and it was at once suggested that the town might be able to make use of this so-called underground stream for sewage disposal. This suggestion was soon taken up by the press of south Georgia, and within a short time Governor Terrell received a number of letters importuning him to interfere to prevent the Quitman authorities from using deep wells for sewerage purposes.

At the request of the Governor, the writer, who at that time was engaged in the study of the underground waters of Georgia for the State and the United States Geological Survey, made a trip to Quitman to investigate the reports and, if they should be found true, to point out to the people of Quitman the possibility that such a sewerage system might contaminate the wells and springs in that region. When the writer arrived at Quitman he found that the town authorities were seriously considering the question of disposing of the sewage as reported. They were willing, however, to give up the idea of using the supposed underground stream for sewerage purposes if it could be shown that such use would prove injurious in any way whatever. Furthermore, they were willing to cooperate with the State and the United States surveys by paying the greater part of the expense of any experiments that might be necessary to establish this fact.

After some delay, arrangements were finally made with the United States Geological Survey for conducting an experiment to determine the possibility of contamination of adjacent wells and springs, the plan adopted for this purpose being what is known as the chlorine method of tracing underground watercourses.

The well into which the chlorine (sodium chloride, common salt,)

was introduced in carrying out this experiment was the Russell Pond well, referred to above. The well has a depth of 120 feet, and shows the following section:—

Section of well at Russell Pond, near Quitman, Ga.

	Feet
1 Surface sand	2
2 Varicolored clay	60
3 Yellow sand	15
4 Gray sandy clay	43
5 Limestone (water-bearing).	

The water, which rises to within about 77 feet of the surface, comes from the cavernous limestone found in all of the deep wells of Quitman and vicinity.

GEOGRAPHY AND GEOLOGY

Before the experiment is described in detail a few general notes will be given on the geography and geology of the region, both of which have a certain bearing on the question under consideration.

That part of South Georgia covered in conducting the Quitman experiment lies along the Georgia-Florida line, and includes the southern part of Brooks and the adjacent portions of Thomas and Lowndes counties. This part of the State is comparatively level, but in parts of Brooks county the surface is more or less rolling, and depressions caused by lime sinks are occasionally seen. The streams, which all flow southward, are usually sluggish, and at points in their course frequently traverse cypress swamps of considerable extent. The springs of the region are few in number, but are usually large. They are generally found in or near the larger streams, and are often submerged during the wet season.

The geology of the region is typical of the portion of south Georgia that lies along the State line west of Thomasville, and that has been described by Spencer and others. Nearly everywhere throughout the piny woods or the cultivated fields of this section is to be seen a superficial covering or veneer of fine sand, which at some points attains a thickness of 2 feet or more. This sand corresponds

probably to McGee's Columbia formation, as it lies directly upon the orange and reddish Lafayette clays.

The Lafayette clays, which are well exposed in numerous cuts along the Coast Line Railroad both east and west of Quitman, are usually stratified below and massive above. On the more elevated lands they attain a thickness of many feet, but along the larger

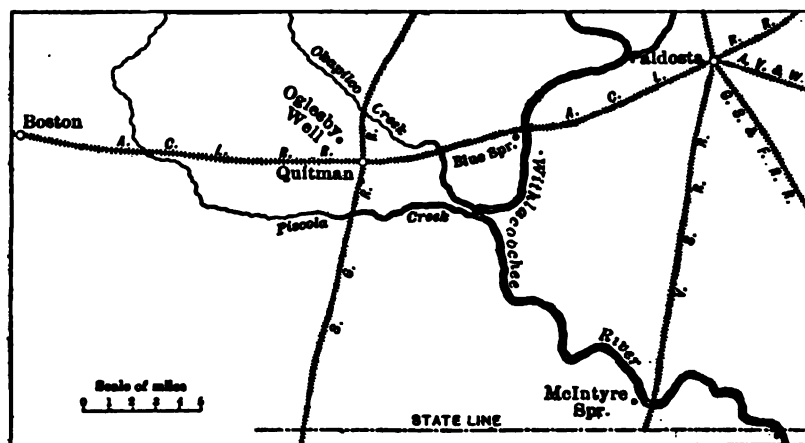


FIG. 5.—Sketch Map showing Location of the Quitman Experiment.

streams they have been partially or wholly removed by erosion so as to expose underlying clays, which at certain points along Withlacoochee River, notably at McIntyre Spring, contain large masses of coral. These lower clays are probably Miocene, and belong, no doubt, to Langdon's Chattahoochee group.

Beneath these Miocene clays there is a thick limestone, which is the source of the water supply of all the deep wells at Quitman, Boston, and Valdosta. This limestone seems to belong to Conrad's Vicksburg group, which, according to Dall, forms the lowest member of the Oligocene beds in the southern Tertiary series. As is shown by samples of borings from deep wells, this rock is somewhat variable in character, but seems to consist largely of thick beds of comminuted shells and corals interlaminated with layers of hard, compact limestone. The upper beds of this limestone appear to be

cavernous, for cavities, shown by the dropping of the drill, are frequently found in it in the deep wells throughout the region. These cavities are said to vary in depth from 3 to 9 feet, and are always filled with water having a static head that is 40 feet or more higher than the point at which the cavities are struck.

The order of occurrence and the approximate thickness of these several formations are shown in the section of the Russell Pond well, above given. The Boston and the Quitman wells also show similar sections. The dip of the formations is supposed to be toward the south at a few feet per mile.

DESCRIPTION OF EXPERIMENT

The chlorine method of tracing underground streams, as carried out in the Quitman experiment, was adopted at the suggestion of Prof. C. S. Slichter, consulting engineer of the United States Geological Survey.

A reconnoissance topographic survey of the region surrounding Quitman was made, with the view of finding all springs and wells whose waters stood at a lower level than the water in the Russell Pond well, where the salt was to be introduced, altitudes being determined by aneroid barometer. From all such springs samples of water were collected for determination of the amount of chlorine present. Each of the springs and wells thus sampled was made a station from which, at regular intervals, samples of water were collected by observers who were advised how and when to collect samples. The various stations having been established and samples collected for the determination of the normal amount of chlorine contained in the waters, 2 tons of salt (sodium chloride) were introduced into the Russell Pond well. The salt was put into the well in the form of solution, its introduction beginning at 8 a. m. October 15, and continuing until 8 p. m. October 20. The first ton of salt put into the well was introduced continuously for twelve hours at the rate of $166\frac{2}{3}$ pounds an hour, while the second ton was put into the well continuously for one hundred and twenty hours, or five days, at the rate of $16\frac{2}{3}$ pounds an hour.

In order to introduce the salt into the well at the above rate and also to insure as complete saturation of the water as possible, five 50-gallon barrels were set about 20 inches apart upon a level platform at the well and connected with one another by pieces of 2-inch iron pipe, firmly screwed into the barrels by right and left screws cut on their opposite ends. The iron pipe was inserted into the barrel nearest the well about 2 inches from the bottom, while the pipe between each succeeding barrel was elevated about 4 inches, so that the one uniting the last two barrels entered them about halfway up. When everything was in readiness for the experiment to begin, each barrel was filled with salt up to the point at which the outflow pipe entered it. The water was then turned into the barrel farthest from the well through a hydrant connected with the public water supply. As the water rose in this barrel to the point of entrance of the pipe it flowed into the next barrel, and so on until the entire chain of barrels was filled. The water now being more or less completely saturated, having flowed over the salt in the bottom of each barrel, was turned into the well through a stopcock so adjusted as to deliver the desired amount of water per minute. By a nice adjustment of the stopcock at the well and of that at the hydrant it was found that this plan of delivering a given amount of brine to the well in a stated time was practically automatic, the attendant having nothing to do except to keep the bottoms of the barrels supplied with salt.

DESCRIPTION OF STATIONS

The stations from which water was collected were seven in number and are described below. Their locations are shown by the sketch map (fig. 5).

Station No. 1. — The station is the well at the public water-works, 1,000 feet northeast of the Russell Pond well. The well is 321 feet deep and supplies the town with water. It is cased with 8-inch casing to 122 feet, only a short distance above the first water-bearing stratum. Within the 8-inch casing is inserted a 4½-inch casing which extends from the surface to a depth of 309 feet, at which point it was driven securely into a hard rock so as to form what was supposed to be a water-tight joint, cutting off all the water from the



BLUFF AT DOCTORTOWN, WAYNE COUNTY, GEORGIA, SHOWING THE CONTACT OF THE ALTAMAHA GRIT AND THE UNDERLYING MIOCENE FORMATION.

123-foot water-bearing stratum above. The town water supply is pumped through this $4\frac{1}{2}$ -inch casing from the second water-bearing stratum, 311 feet below the surface. The second water-bearing stratum has a static head $2\frac{3}{4}$ feet greater than that of the first stratum. Nevertheless, it was thought that in case the $4\frac{1}{2}$ -inch casing was not absolutely water-tight at the point where it was driven into the rock, continuous pumping might lower the static head of the water from the second stratum sufficiently to set up a current from the stratum above, in which event sewage introduced into the upper stratum would contaminate the lower.

Station No. 2. — This is the "Old City well," 1,500 feet northeast of the Russell Pond well. The well used for this station is 500 feet deep, and was completed in 1884. It was originally cased to a point some distance below the first water-bearing stratum, but its lower part becoming obstructed by sand or some other material, the 6-inch casing was burst by an explosive at the first water-bearing stratum, in order to obtain water for public use. While the experiment here reported was being carried on, this well, which had not been in use for some months, was connected with the pumps at the water-works station, so that the water might be procured at regular intervals.

Station No. 3. — This is the Oglesby well, located at the Oglesby Mills, three-fourths of a mile northwest of Quitman. This well was completed in May, 1903, and is only 92 feet deep. It is 6 inches in diameter and is cased to 78 feet. The water-bearing stratum was struck at 87 feet, at which point, it is said, the drill dropped into a cavity 4 feet in depth and immediately thereafter the water rose to within 48 feet of the surface. It will here be noted that the water-bearing stratum in the Oglesby well is much nearer the surface than the first water-bearing stratum encountered in the wells within the corporate limits of Quitman, and also that the static head of the water is nearer the surface. This difference, however, is due entirely to the fact that the ground at this point is lower than that at neighboring wells, and not, as might be supposed, to the occurrence of a different water-bearing stratum.

Station No. 4. — This station was established at Blue Spring, near the right bank of the Withlacoochee River, 6 miles east of Quitman. By aneroid measurement the spring was found to be about on a level with the static head of the water in the Russell Pond well, so that it seemed to be a possible outlet for the supposed underground stream into which the salt was introduced. At the time the samples were collected Blue Spring was flowing approximately 15,000,000 gallons in twenty-four hours. It was learned, however, that at one time during an extremely dry season, several years ago, the spring entirely ceased flowing.

Station No. 5. — This is McIntyre Spring, about 15 miles southeast of Quitman, only a short distance from the Georgia-Florida line. The spring is located partially in the Withlacoochee River and appears to furnish a much greater volume of water than Blue Spring. Owing to the great distance of this spring from Quitman it was found impracticable to determine its elevation by aneroid barometer, but judging from the fall of the river it must be several feet below Blue Spring. A flood in the river during the time the samples were being collected submerged McIntyre Spring for some time, so that only a limited number of samples were procured from this station.

Station No. 6. — This is a deep well at Boston, Thomas county, 14 miles west of Quitman. The Boston well has a depth of 290 feet and was completed in June, 1900. It is reported that three water-bearing strata were penetrated in this well, at 120, 160, and 286 feet. The static head of the water in the third water-bearing stratum is said to be 69 feet above sea-level, which is 70 feet below the static head of the water in the Russell Pond well.

Station No. 7. — This station is one of the deep wells at Valdosta, 17 miles east of Quitman. The well from which the samples were taken at Valdosta was the 8-inch well, now used to supply the city water-works. This well is 500 feet deep, but its main water-supply is said to come from a stratum at a depth of 260 feet, where the drill is reported to have entered a cavity 4 feet in depth. The static head of the water now in this well is 105 feet above sea-level, which is 24 feet below the static head of the water in the Russell Pond well.

Additional Station. — In addition to the stations here described there was also one kept up for a short time at the Quitman cotton factory; but, as the well was afterwards found not to be of sufficient depth to reach the water-bearing stratum into which the salt was introduced, it has been omitted in the tables showing the variation of chlorine in the samples of water collected at the various stations.

SAMPLES OF WATER TAKEN

The time at which the samples of water were taken at each station, the intervals between samples, and the number of samples themselves are shown in the following table: —

Place, time, and number of samples of water taken

STATIONS	Date of First Sample	Interval between Samples	No.
		<i>Hours</i>	
No. 1.....	Oct. 15, 12 noon.....	4	36
No. 2.....	do.....	4	31
No. 3.....	Oct. 15, 4 p. m.	8	30
No. 4.....	Oct. 16, 6 a. m.....	12	40
No. 5.....	Oct. 19, 6 a. m.....	24	^a 11
No. 6.....	Oct. 19, 8 a. m.....	24	^b 16
No. 7.....	do.....	24	31

^a Full number of samples not collected on account of high water.
^b Fourteen samples lost by breakage in shipment.

CORRELATION OF WATER-BEARING STRATA

In regard to the different water-bearing strata above noted in the Valdosta and Boston wells it might be stated that it was found impossible, with the meager data at hand, to correlate any of them with the water-bearing stratum in the Russell Pond well. In the absence of other data, an attempt was made to correlate the strata by means of chemical analyses of the water, but the results were unsatisfactory.

While it does not seem possible at present to correlate any of the strata with the Quitman stratum, into which the salt was introduced, there is but little doubt that they all occur in the Vicksburg-Jackson limestone. Furthermore, as previously noted, the static head of the water in the Valdosta and Boston wells is greater than the static head of the water in the Quitman well by 24 and 69 feet, respectively. This would seem to indicate that the water-bearing strata are not continuous throughout the entire region, or that there is a flow converging toward Quitman, a condition not probable.

RESULTS

Station No. 1. — The normal chlorine in the water-works well was determined as 5.44 parts per 1,000,000. Four hours after the introduction of the salt in the Russell Pond well the amount of chlorine in the water, as shown by the samples, began to increase, reaching a maximum of 6.80 at 8 p. m. October 15, or twelve hours after the introduction of the salt. From this time on the water continued to show excess of chlorine in varying quantities for about five days, or as long as the salt water was poured in at the other well, finally subsiding to its normal amount on October 21.

Station No. 2. — The normal chlorine in the old Water-works well appears to be 5.44, although a sample taken just before the experiment showed 6.12. The chlorine content of the water of this well began to rise within four hours after the introduction of the salt, reaching a maximum of 6.97 at 8 p.m. on October 15, from which time it gradually declined, with several fluctuations, until 8 p.m. October 19, after which it remained constant until October 21, at its normal amount.

Station No. 3. — The normal chlorine in the Oglesby well is 5.44. The water of this well was examined at intervals from October 15 to October 29. From October 15 to October 21 there were some fluctuations in the amount of chlorine, which, however, appear to have no relation to the introduction of the salt in the Russell Pond well. At 12 p. m. on October 21 a decided rise was noticed, which continued until 4 p. m. October 22, when it reached a maximum of 6.46. It remained at this point until 12 p. m. of the same day, after

which it declined gradually, though with some fluctuations, until 12 p. m. October 26, when the normal was again reached.

Station No. 4. — The normal chlorine at Blue Springs appears to be 5.78 parts per 1,000,000. Tests were conducted from October 16 to November 4, but no variations in the amount of chlorine which could be attributed to the salt inserted at Quitman were observed.

Station No. 5. — The normal chlorine at McIntyre Spring is 5.78, the same as at Blue Spring. Samples were taken from October 19 to November 6, but no variations in the amount of chlorine referable to the introduction of salt at Quitman were noted.

Station No. 6. — The normal chlorine in the Boston well appears to be 6.80, and no persistent variations were observed during the interval from October 19 to November 24.

Station No. 7. — The normal chlorine in the Valdosta well is 5.44. No variations due to the insertion of salt at Quitman were noted.

From the preceding it will be noted that only three stations — namely, the Water-works well, the Old City well, and the Oglesby well — show variations which can with any degree of certainty be attributed to the effect of salt introduced in the Russell Pond well. It will be observed that the maximum amount of chlorine in the two wells first named occurred at 8 p. m. October 15, just twelve hours after the first introduction of salt into the well. As both of these wells are within a short distance of the Russell Pond well, this result would naturally be expected; yet at the same time it is difficult to explain how the salt made its appearance in the Water-works well, as it obtains its supply from a water-bearing stratum that lies 200 feet below the one into which the salt was introduced. It was surmised that the casing cutting off the upper water-bearing stratum from the one below did not form a water-tight joint at the point where it was driven into the rock, but allowed the water to flow downward when the pump was in action. In order to determine whether this supposition was true or not, the following test was made: — The pump was started and run for a few minutes when a sample of the water was taken to determine the normal amount of chlorine present. There was then introduced through the 8-inch cas-

ing into the upper water-bearing stratum 15 pounds of salt in solution, and the pump was again started and run continuously for a half hour. During the time the pump was in operation samples were taken every five minutes. Analyses of these samples showed no increase of chlorine, demonstrating that the salt had not reached the second water-bearing stratum by the way of the suspected joint at the lower end of the 4½-inch casing elsewhere described. This test seemed to show that the chlorine in the original experiment did not reach the water in the second stratum by the way of any defect of the joint at the end of the 4½-inch casing. The test, however, can hardly be considered conclusive, owing to the small amount of salt used and the limited time the pump was operated after the salt was introduced. It is very probable that if the amount of salt had been larger and the samples had been taken at longer intervals, the presence of the salt would have been detected.

In regard to the Oglesby well it will be noticed that the salt was transmitted in a northwesterly direction, notwithstanding the fact that the general flow of underground waters of the region is supposed to be southward rather than northwestward.

In addition to the variation in the amount of chlorine here explained as probably due to the presence of the salt introduced into the Russell Pond well, there are also other variations which, with one exception, are unexplained. The exception referred to occurred at the old City Water-works well. The diagram for this well shows that the amount of chlorine in the samples taken before the experiment was much higher than the normal. This was probably due to the presence of surface waters which had reached the water-bearing stratum below through the defective casing.

CONCLUSIONS

From the notes above given on the Quitman experiment the following conclusions may be drawn:—

1. The so-called underground stream, in the ordinary meaning of that term, does not exist in the wells investigated.
2. The water, which has a motion of probably not over 200 feet

per hour, occurs in a porous, cavernous limestone, several feet in thickness.

3. Sewage introduced into the first water-bearing stratum will contaminate all of the wells in the vicinity that attain a depth of 120 feet or more.

4. The upper water-bearing stratum in the Water-works well is not completely cut off from the water-bearing stratum below, so that the water from the lower stratum is likely to be contaminated from the stratum above.

CHAPTER XIII

BLOWING SPRINGS AND WELLS OF GEORGIA

The blowing springs and wells of Georgia may be divided for convenience of description into two classes: (1) those in which the air passes inward for a time, and after a short period of quiescence reverses its course; (2) those in which the amount of the air is constant and moves in one direction only. One of the best illustrations of the former class of springs is the Grant Blowing Spring near Chattanooga, a description of which is as follows:—

THE GRANT BLOWING SPRING is located at the base of Lookout Mountain, near the Georgia-Tennessee line, about three miles from the corporate limits of Chattanooga. The spring has long been known, and is much frequented by tourists visiting Chattanooga. It may be reached by the Alton Park electric cars, which stop only a few hundred yards north of the spring, or by the Chattanooga Southern Railway. The proximity of the spring to Chattanooga and its accessibility have doubtless added much to its notoriety.

In general appearance, the spring is not unlike many other bold springs met with along the eastern base of Lookout Mountain. It flows from a fissure, at the base of a limestone bluff, forming a good sized stream. The spring itself reveals but little evidence of the phenomenon for which it is noted. Nevertheless, the phenomenon can readily be detected by holding a smouldering match or lighted paper near the opening from which the water flows. The motion of the air is to be seen in its full force at an opening in the bluff above, about forty feet distant; and at an elevation of ten or fifteen feet above the spring. At this opening, which leads down to the



BLOWING CAVE, DECATUR COUNTY, GEORGIA. THE AGITATED LEAVES ABOVE THE MOUTH OF THE CAVE SHOW THE EFFECT OF THE ESCAPING CURRENT OF AIR.



stream supplying the spring, there is, at times, a strong current of air passing inward or outward, depending on the atmospheric conditions hereafter to be discussed. The writer was informed by Mr. W. H. Grant, the present owner of the spring, that the opening, above referred to, was formerly of sufficient size to admit the body of a man, and furthermore that he, together with a civil engineer some years ago, entered the opening which leads into a cave having large chambers fifteen feet or more in height. The distance, to which the cave was explored by Mr. Grant and his companion, was not measured, but it was estimated to be nearly a mile. The direction of the cave is said to extend southward parallel with Lookout Mountain. Mr. Grant reported that they noticed no current of air in the cave. This, however, may be accounted for by their using a lantern, which would not be affected except by a strong draught. The stream forming the spring was found traversing the cave, as far as the exploration extended; and many stalactites and stalagmites were reported in the larger chambers.

The formation, in which the cave occurs and from which the spring flows, is one of the lower members of the Carboniferous rocks, known as the Bangor limestone. It consists of very pure, heavy-bedded blue or gray limestone, which attains a thickness, in the neighborhood of Chattanooga, of about 800 feet. In the immediate vicinity of the blowing spring, the Bangor limestone dips at a low angle westward toward the axis of Lookout Mountain. It forms the base of the mountain, and, in places, extends 400 feet or more up its slope, the last outcropping being seen only a short distance below the first line of sandstone bluffs. Underlying the Bangor limestone and extending down to the Devonian black shale below, is about 200 feet of siliceous limestone, belonging to the formation known as the Fort Payne chert. Both of these formations are highly soluble in carbonated waters; and they frequently give rise to limestone sinks and caves of greater or less extent. This is especially true of the former, which contains but little silica or other insoluble material.

At the writer's suggestion, Mr. Grant made a series of observations on the blowing spring in order to determine the time and direction of the air currents together with the relative temperature of the water flowing from the spring and the outside air. The results of the observations, which extended from December 21 to December 26, 1905, inclusive, are embodied in the following table: —

TABLE NO. I

DATE	TIME		TEMPERATURE		DIRECTION OF WIND	
	A. M.	P. M.	Air	Water	In	Out
Dec 17	8		44°	38°	Strong	Weak current
19	9		42°	50°	Very weak	
20	8		46°	51°	Strong	
20		4	44°	51°	Not so strong	
21	8		46°	52°	Weak	
21	noon		50°	55°	Strong	
21		4	48°	55°	Strong	
22	8		36°	54°	Strong	
22	noon		52°	56°	No current	
22		4	46°	56°		
23	8		43°	56°	Strong	
23	noon		42°	54°	Strong	
23		4	40°	56°	Strong	
24	8		27°	53°	Strong	
24	noon		38°	54°	Strong	
24		4	33°	55°	Strong	
25	8		28°	52°	Strong	
25		4	38°	56°	Not so strong	
25		10	30°	55°	Strong	
26	4		26°	54°	Very strong	

The following barometric readings, furnished by Mr. L. M. Tindell, Officer-in-charge, U. S. Weather Bureau, Chattanooga, Tenn., show the variations of the atmospheric pressure during the time of Mr. Grant's observations: —

TABLE NO. 2

Hourly Barometric readings, U. S. Weather Bureau, Chattanooga, Tenn., December 17 to 26, 1905, Inclusive

Hour	17	18	19	20	21	22	23	24	25	26
1 a. m.	29.37	29.26	29.21	29.20	28.85	29.30	29.09	29.35	29.42	29.42
2 a. m.	.36	.27	.22	.21	.87	.30	.07	.36	.42	.45
3 a. m.	.36	.28	.24	.20	.90	.30	.06	.34	.42	.45
4 a. m.	.36	.26	.24	.19	.42	.30	.08	.34	.42	.45
5 a. m.	.36	.26	.25	.18	.94	.33	.09	.34	.42	.45
6 a. m.	.36	.25	.26	.08	.97	.33	.13	.35	.43	.45
7 a. m.	.37	.24	.26	.10	.28	.3	.13	.36	.43	.44
8 a. m.	.38	.24	.28	.12	29.02	.34	.15	.37	.44	.45
9 a. m.	.39	.25	.28	.10	.04	.34	.20	.39	.45	.47
10 a. m.	.40	.25	.28	.05	.05	.34	.24	.39	.44	.47
11 a. m.	.38	.25	.26	.03	.05	.32	.24	.38	.43	.45
12 n.	.36	.21	.24	28.99	.05	.28	.25	.37	.40	.41
1 p. m.	.33	.20	.23	.98	.05	.24	.24	.36	.38	.37
2 p. m.	.32	.20	.22	.92	.06	.22	.24	.36	.38	.35
3 p. m.	.31	.20	.22	.92	.08	.22	.26	.36	.38	.34
4 p. m.	.31	.19	.22	.94	.10	.21	.26	.36	.39	.33
5 p. m.	.32	.19	.22	.92	.13	.19	.28	.37	.40	.33
6 p. m.	.32	.20	.24	.85	.18	.19	.29	.40	.42	.33
7 p. m.	.3	.19	.4	.81	.21	.19	.30	.41	.43	.32
8 p. m.	.31	.21	.23	.84	.24	.18	.32	.42	.44	.32
9 p. m.	.30	.22	.23	.85	.25	.15	.33	.44	.45	.32
10 p. m.	.30	.23	.23	.85	.29	.14	.34	.44	.45	.32
11 p. m.	.29	.23	.30	.85	.29	.11	.33	.43	.45	.33
12 mid.	.27	.23	.24	.84	.29	.06	.33	.42	.45	.32

BLOWING CAVE OF DECATUR COUNTY. — Another phenomenon, which may be classed with blowing springs of the first class, is the Blowing Cave of Decatur county, located about ten miles north of Whigham. This cave occurs in the upper layers of the Vicksburg-Jackson limestone, a calcareous formation of great extent, constituting one of the most important divisions of the Tertiary rocks of South Georgia. The formation is noted for its large springs, and, also, for its numerous limesinks and underground streams. It consists mainly of porous fossiliferous limestone, which has a gradual dip to the southward.

The Blowing Cave is situated in a typical Vicksburg-Jackson limestone-sink region, about three quarters of a mile distant from what is known as the Water Falls, a deep circular limesink into which a good sized stream cascades and disappears underground. In the immediate vicinity of the cave, which is located in a cultivated field,

the surface is somewhat undulating, due apparently to surface erosion. A clump of hickories and pines marks the exact spot of the Blowing Cave. It is situated on the side of a shallow, somewhat circular limesink, about 100 feet in diameter and less than 20 feet deep. On the south slope of the sink, just above the cave, is an exposure of limestone forming layers two feet or more in thickness.

The Blowing Cave itself is very inconspicuous in its quiescent state, and might be taken for a rabbit's burrow. It is said that its opening, now choked with stones and partially decomposed leaves, was formerly much larger, and that the phenomenon for which it is noted, acted with greater force. At the present time, there are visible only three small openings, or crevices, with a combined cross sectional area of less than 50 square inches. Through these crevices, at the time of my visit at 2 p.m., December 12, 1905, the air was passing outward with such force, that leaves and other light material thrown into the opening were immediately blown out. The air within was much colder than the outside air, and it readily condensed the breath of a person standing near the cave. As the early morning was chilly and the afternoon was warm, I would say that the outflowing air more nearly approached the former temperature than the latter. However, as I had no thermometer, I was unable to verify this statement. The sound produced by the air escaping from the opening was to be distinctly heard thirty feet away. I was informed by a colored man, who lived near by, that the air passed into the cave in the forenoon and reversed its direction in the afternoon. No definite information was secured, relative to the atmospheric conditions during the inflowing and outflowing of the air, but, judging from the general statement made by the colored man, the action of the air is governed by the daily variation of atmospheric pressure.

THE BOSTON WELL. — The Boston deep well belongs to the second class of blowing wells, namely, wells in which the direction of the air is in only one direction. Boston, the town in which the well is located, is on the Atlantic Coast Line Railroad, in the southeastern part of Thomas county, 12 miles east of Thomasville. It has an elevation of 198 feet above sea-level. The surface of the surround-

ing country is comparatively level, though limesinks, produced by the subterranean streams are occasionally met with. The prevailing rock of the region is Vicksburg-Jackson limestone, overlain by a considerable thickness of clay and sand, the upper part of which seems to be Lafayette, while the lower part is probably Altamaha grit. The thickness of these sands and clays in the Boston well is 90 feet; but, at many places near the streams west of Boston, they have been removed by erosion, and the Vicksburg-Jackson limestone appears at the surface.

The Boston deep well, which is six inches in diameter, has a depth of 290 feet. Water was reported at 120, 160 and 286 feet, respectively. The main water-supply at present is said to come from a subterranean stream in the limestone, at 120 feet. The casing extends to 110 feet. The static head of the water in the well, when completed, was 128 feet from the surface, or eight feet below the subterranean stream. Shortly after the completion of the well, Mr. W. Z. Brantley, the mayor of the town, discovered that there was a continuous draft of air passing down the casing; and, by placing his ear near the mouth of the well, he was able to detect a sound like running water. This indraft, Mr. Brantley reports, was quite strong; and it continued as long as the well was left open. I was unable to verify Mr. Brantley's statement at the time of my visit, owing to the well being connected with the pump which supplies the town with water.

A similar well to the above, though exhibiting no sucking phenomenon, is the first deep well put down at Quitman. This well penetrated, at a depth of 90 feet from the surface, a cavity in the Vicksburg-Jackson limestone, three feet deep, in which flows a swift stream, that could be distinctly heard several yards from the mouth of the well.

THE LESTER WELL. — This well, reported by Mr. William Miller, is also similar to the Boston well. It occurs on Mr. B. E. Lester's plantation, 20 miles south of Thomasville, near Iamonia lake. Mr. Miller, in describing this well, says that, at the depth of 154 feet, he struck a stream of water running so swiftly, that he could not pass a 2-pound iron plumb-bob, attached to a fishing-line,

through it. He reports blowing crevices in the well at 87, 124 and 144 feet. When the well was being bored, the air from each of these cavities is said to have passed in, in the forenoon, and out, in the afternoon; but, after the completion of the well to the swift moving, subterranean stream, the air ceased to pass outward, but was sucked in, with a strong, steady pull, drawing the flame and smoke of a torch down the casing when held six inches above its opening. This well is cased to 70 feet, below which point it is said to penetrate a soft white limestone.

FOREST FALLS. — Forest Falls is located in Decatur county, seven miles north of Whigham, and about three miles south of Blowing Cave. The geological conditions, met with in the vicinity of the Falls are practically the same as at Blowing Cave. The surface is somewhat rolling; and, with the exception of a superficial layer of sands and clays, about 30 feet in thickness, the formation consists of Vicksburg-Jackson limestone. The height of the falls is about 70 feet, and the water makes its descent in a single plunge. The stream forming the falls is small, furnishing not over 400 cubic feet of water per minute. The water, after its descent into the somewhat funnel-shaped limestone sink, makes its escape, as a rapidly flowing stream, into a subterranean opening a few yards to the south, and about eight feet below the base of the falls. At the time of my visit, the rapidly flowing water filled the mouth of this subterranean opening with the exception of a space of about four inches. A pine torch, held near the opening, showed a perceptible and constant indraft of air. Almost immediately underneath the falls and at an elevation of about 12 feet above this opening, is a second opening, which is apparently an additional outlet to the limesink when the stream is swollen by heavy rains. The latter opening, like the former, also showed an indraft of air. Directly in front of the falls, as well as at each side, there is a strong current of air, both outward and upward. An attempt was made, by the use of an aneroid barometer, to ascertain the difference between the air pressure at the base of the limestone sink and the air outside of the influence of the falls; but, owing to the poor condition of the instrument used, the results were unsatisfactory.

BUBBLING SPRINGS. — These springs, which may be classed with continuous blowing¹ springs, are confined chiefly to the Knox dolomite series of Silurio-Cambrian rocks of Northwest Georgia. They often furnish a considerable volume of water, which almost invariably boils up through a bed of white sand. A good illustration of the bubbling springs, here referred to, is the Lukens Spring, located near the Southern Railway in Whitfield county, one mile south of Dalton. The spring is quite large; and it is reported to furnish several hundred gallons of water per minute. The bottom of the spring is covered with a layer of white sand, which the water continuously agitates, as it forces it way upward through many small openings. Coming up with the water, at somewhat irregular intervals, are numerous bubbles of air. The total volume of air forced up in twenty-four hours is considerable, and only a short time is required to collect a sufficient amount for examination. As far as I was able to learn, the escape of air was quite constant, and unaffected by atmospheric conditions.

Another bubbling spring of like nature is the Kerr Spring in Bartow county, about half-a-mile south of Hall station. The conditions and the phenomenon here exhibited are so similar to those at the Lukens Spring, that it is unnecessary to describe them.

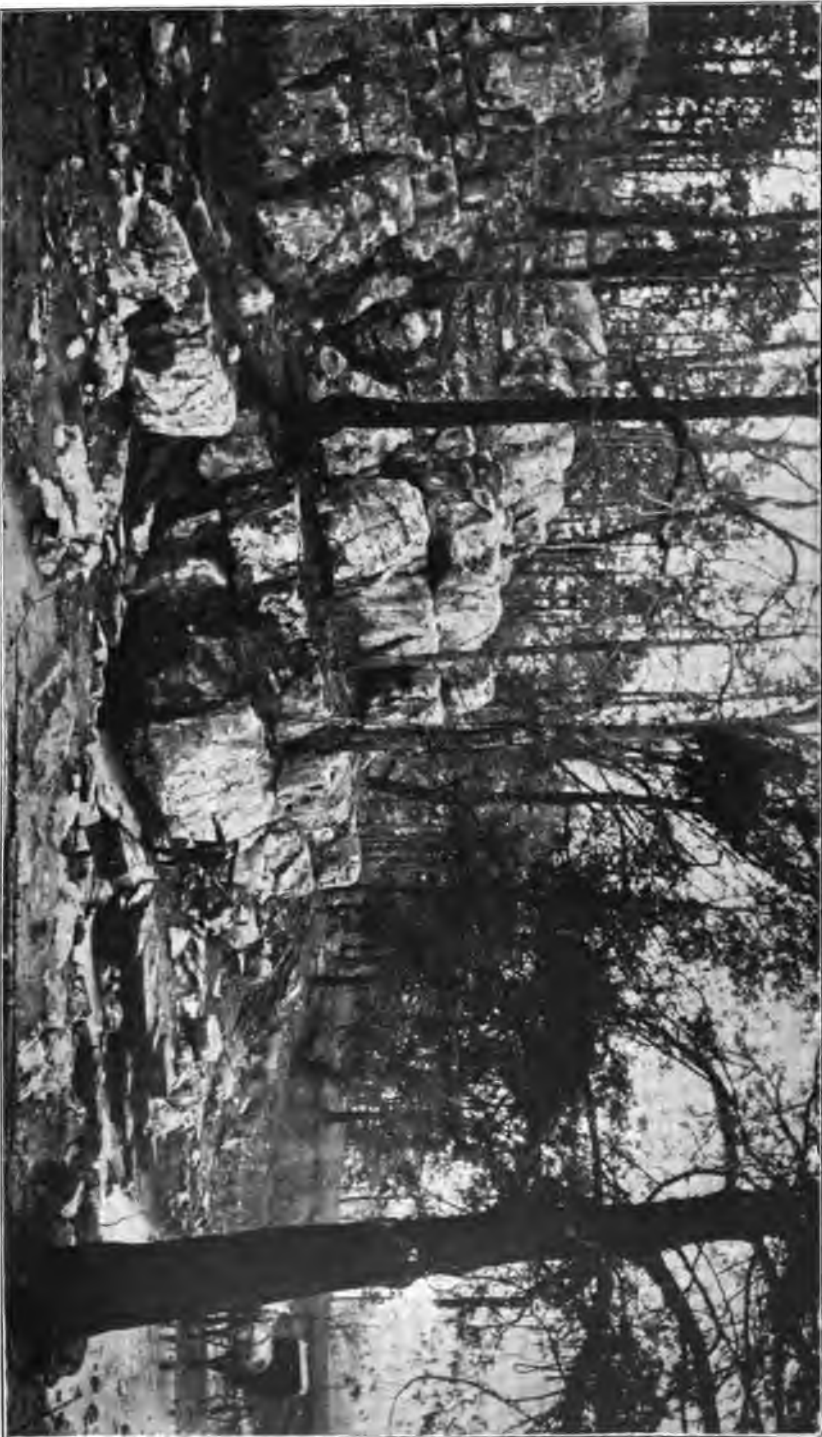
CAUSES OF BLOWING SPRINGS AND WELLS. — The two classes of blowing springs and wells above described appear to be due to two entirely different causes. The cause of the first class of which the Grant Blowing Spring and the Blowing Cave of Decatur county are good types seems to be due entirely to the difference of atmospheric pressure on the outside and the inside of the cave.

At the time of my first visit to the Grant Blowing Spring, I was of the opinion that the relative temperatures of the air on the inside and on the outside of the cave had something to do with the air currents, but the spring record furnished by Mr. Grant (see table No. 1) shows that the direction of the currents has nothing whatever to do with these relative temperatures. That these currents are due solely to the variation of atmospheric pressure appears to be conclusively demonstrated by comparing tables No. 1 and No. 2.

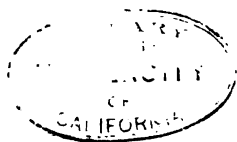
The first of these tables shows, with only two exceptions, that at

the time when the observations were made there was an ingoing current. Table No. 2, which gives the barometric readings, shows that the time of recorded ingoing currents was during the time of increasing atmospheric pressure, and in the two exceptional cases, which showed outgoing or no currents, the atmospheric pressure was decreasing. In other words the outgoing currents always take place during rising barometer, and the ingoing currents during falling barometer. As the atmospheric pressure increases daily from 4 a. m. to 10 a. m. and decreases from 10 a. m. to 4 p. m., it follows that springs, wells and caves of this class will have an indraft in the forenoon and an outdraft in the afternoon. If the daily variations of atmospheric pressure were regular, the ingoing and outgoing currents would also be regular and would take place at the same time each day. However, as the daily maximum and minimum barometric readings may vary greatly from day to day, due to approaching storms or other causes, the ingoing and outgoing currents will not always take place at the same time each day, nor will they always act with the same energy.

In the second class of wells and springs, the constantly outgoing or the constantly ingoing current is entirely independent of atmospheric conditions. The currents whether outward or inward act with equal energy during high or low barometer, and always move in the same direction. The Boston and the Lester deep wells and the Lukens and the Kerr springs are excellent examples of wells and springs of this class. The phenomenon which they exhibit seems to be due entirely to the friction of the air on the rapidly moving current of water. This phenomenon is beautifully illustrated in the Richards water blast to be found in every well equipped chemical laboratory. In the Boston well, and also in the Lester well, appear almost exactly the same conditions met with in Richards water blast. The well itself forms the inlet for the air and the rapidly flowing stream in the subterranean channel completes the conditions necessary for an ingoing air blast. As the air in the wells here named is constantly drawn in, it naturally follows that it must escape at some other point as an outgoing current, thus giving rise to continuously blowing caves or springs, or even to bubbling springs as the Lukens and the Kerr springs.



BLOWING SPRING, WALKER COUNTY, GEORGIA, NEAR CHATTANOOGA, TENNESSEE.



It will be seen by the description of the Quitman deep well that not all deep wells penetrating subterranean channels with swift flowing streams are blowing or sucking wells. This may be accounted for by the channel being only partially filled with water, and the air being able to circulate freely within. The essential conditions of continuous suction in wells is that the air once dragged into the underground stream by the friction of the water can not again reach the point of intake.

The current of air above noted at the entrance of the caverns at Forest Falls is also due to the friction of the air and water, but as the air is free to escape upward through the mouth of the limesink, the current is feeble. In this instance if the water at the base of the falls were to escape into a subterranean chamber and the accompanying air could not escape by the way of its entrance it would give rise to a strong blast. As underground streams frequently pass from one bed of rock to another in their subterranean course, they no doubt often form waterfalls which possess all of the essential conditions necessary for producing an air blast and thus give rise to continuously blowing caves or springs.

APPENDIX A

SOURCE OF WATER SUPPLY OF CITIES AND TOWNS

In the following table, statistics relating to the sources of water supply of 184 cities and towns of Georgia, are given. Every ordinary source, including ponds, streams, springs, artesian wells, dug wells, driven wells, and cisterns, is utilized. In general the supplies are reported as of ample volume and of satisfactory quality. This is especially true of the deeper wells of the Coastal Plain and of springs. In certain valleys, however, the surface deposits are of such a nature that not only are the underground waters likely to be contaminated, but also, because of the nature of the material, are not perfectly filtered. Occasionally epidemics of typhoid fever have been known to occur in such localities. In many of the crystalline rocks, especially where the soil or disintegrated rock is absent, the water enters cracks directly without filtration, and may work its way rapidly into wells. Except in the larger cities, however, pure water can usually be obtained from mountain streams or springs with very little trouble.

Sources of water of
[Reported]

No.	County	Locality	Most common source	Other sources	Most satisfactory source	Source of public supply
1	Appling.....	Baxley.....	Artesian wells...	Shallow wells...	Artesian wells...	Artesian wells...
2	.....do.....	Haslehurst.....	Driven wells.....	Wells.....	Neither.....	None.....
3	Baker.....	Newton.....	Artesian wells...	None.....	Artesian wells...	Artesian wells...
4	Baldwin.....	Stephens pottery.	Springs.....	Ponds.....	Springs.....	Springs.....
5	Bartow.....	Adairsville.....	Wells.....	Springs.....	Wells.....	Wells.....
6	.....do.....	Cartersville.....	Etowah River...	Wells.....	River.....	River.....
7	.....do.....	Kingston.....	Wells.....	None.....	Wells.....	Wells.....
8	.....do.....	Stilesboro.....	Cisterns.....	Wells.....	Cisterns.....	Cisterns.....
9	Brooks.....	Quitman.....	Artesian wells...	Shallow wells...	Artesian wells...	Artesian wells...
10	Bryan.....	Pembroke.....	Wells.....	Driven wells...	Wells.....	Wells.....
11	Bulloch.....	Register.....	.....do.....	Springs, stream.	.....do.....	.....do.....
12	Burke.....	Girard.....	Wells.....	None.....	Wells.....	Wells.....
13	.....do.....	Rogers.....	Artesian wells...	Shallow wells...	.....do.....	Artesian wells...
14	.....do.....	Waynesboro.....	.....do.....	.....do.....	Artesian wells...	.....do.....
15	Butts.....	Indian Springs.	Springs.....	Wells.....	Springs.....	Springs.....
16	Calhoun.....	Arlington.....	Artesian wells...	Shallow wells...	Artesian wells...	Artesian wells...
17	Camden.....	St. Mary's.....	.....do.....	Driven wells...	.....do.....	.....do.....
18	.....do.....	Satilla Bluff.....	.....do.....	.....do.....	.....do.....	.....do.....
19	Campbell.....	Palmetto.....	Wells.....	None.....	Wells.....	Wells.....
20	Carroll.....	Bowdon.....	.....do.....	.....do.....	.....do.....	.....do.....
21	.....do.....	Carrollton.....	.....do.....	Springs.....	Springs.....	.....do.....
22	.....do.....	Whitesburg.....	.....do.....	None.....	Wells.....	.....do.....

¹ The data contained in this table was first published by the U. S.

Georgia cities and towns.

in 1938]

Own- ership	Suffi- ciency of supply	Quality	Source of contami- nation	New supplies contem- plated	Range of depths of wells		Depth to principal wa- ter supply	Material in which water occurs	Height of water above (+) or below (-) mouth of wells	Special uses	No
					From	To					
City	Ample	Soft	None	None	20	40	25	Sand		Manufactur- ing.	1
	Insuffi- cient	do	do	do	320	507	30	Gravel	-15	None	2
	Ample	do	do	do	30	40		Rock	+22	do	3
City	do	do	do	do	800	850	40	Sand		Steam	4
Indi- vidual	do	Hard	do	do	35	40	35	Rock	-20	None	5
City	do	Soft	do	do	20	50	30	Clay	-20	Manufactur- ing.	6
	do	Hard	do	do	26	40	30	do		None	7
	do	Hard	None	do	36	75	65	Lime		None	8
City	do	do	do	do	60	100	120	Clay	-77	Manufactur- ing.	9
Indi- vidual	Insuffi- cient	Soft	do	Artesian well	120	321	15	do		None	10
	do	do	do	do	12	30	10	do		do	11
Indi- vidual	Ample	do	do	do	15	20	15	do		None	12
do	do	Hard	None	do	15	25	15	do		None	13
City	do	Soft	do	do	450	800		Sand		None	14
State	Limited	Sulphur	do	do	480	600	30	Schist	-20	do	15
Indi- vidual	Insuffi- cient	Hard	do	do	25	70	300	Sand	-50	Steam	16
City	Ample	Sulphur	do	do	300	500	480	do	+50	do	17
	do	do	None	do	480	500	480	do	+32	do	18
	do	Hard	do	None	350	365	365	do	+32	do	19
Indi- vidual	do	do	do	do	30	40	35	Clay	-28	None	20
do	do	do	do	do	40	60	40	Sand	-30	Machinery	21
do	Insuffi- cient	Soft	do	River	30	40	30	Clay	-30	Factory	22
Town	do	do	do	Creek	30	50	35	Rock	-20	Ginning	22

Geological Survey, Water-Supply and Irrigation Paper 102, 1904.

Sources of water of

No.	County	Locality	Most common source	Other sources	Most satisfactory source	Sources of public supply
23	Chatham...	Pooler	Artesian wells...	Wells	Artesian wells...	Artesian wells...
24	.....do	Tybee .....	.....do	None .....	.....do .....	.....do
25	Chattooga..	Lyerly	Wells .....	.....do	Wells	Wells
26	.....do	Summerville...	Springs	Wells	Springs	Springs
27	.....do	Trion factory..	Wells	River, springs..	.....do .....	.....do
28	Cherokee...	Ball Ground...	.....do	Springs	Wells	Wells
29	.....do	Canton .....	.....do	None .....	.....do .....	.....do
30	Clarke	Athens	River	Wells, springs..	River	River
31	.....do	Whitehall	Wells	Springs	Wells	Wells
32	Clay	Bluffton .....	.....do .....	.....do .....	.....do .....	.....do
33	.....do	Fort Gaines	Artesian wells...	None .....	.....do .....	.....do
34	Clinch	Argyle	Driven wells....	Wells	Driven wells....	Driven wells....
35	.....do	Dupont	Wells	None	Wells	Wells
36	Cobb	Acworth	Shallow wells ...	Springs .....	.....do .....	.....do
37	.....do	Austell	Wells	None .....	.....do .....	.....do
38	.....do	Marietta	Stream	Wells .....	.....do	Stream
39	Goffee	Willacoochee ...	Driven wells....	Driven wells....	.....do	Driven wells....
40	Colquitt ...	Doerun	Wells	None .....	.....do	Wells
41	.....do	Sigabee .....	.....do	Ponds .....	.....do .....	.....do
42	Coweta	Grantville .....	.....do	Springs .....	.....do .....	.....do
43	.....do	Newnan	Springs .....	.....do	Springs	Springs
44do	Senola	Wells	None	Wells	Wells
45	Dade	New England City.do	Springs	Springs	Springs

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Georgia cities and towns.

Owner-ship	Suffi- ciency of supply	Quality	Source of contami- nation	New supplies contem- plated	Range of depths of wells		Depth to principal wa- ter supply	Material in which water occurs	Height of water above (+) or below (-) mouth of wells	Special uses	No.
					From—	To—					
Town ...	Ample...	Soft	None .....	.....	Ft. 460	Ft. 480	.....	Shell-bed	.....	Steam en- gines.	23
...do .....	...do	Sulphur.	...do	None	155	160	155	.....	+15	None	24
Ind i- vidual.	...do	Hard .....	...do .....	.....	20	30	25	Lime- stone.	-10	.....	25
.....	.....	...do .....	...do	None	25	40	30	...do	-20	None	26
Town ...	Ample...	...do .....	...do .....	...do	40	50	40	.....	-30	Milling.....	27
Ind i- vidual.	Insuffi- cient.	Soft .....	...do .....	...do	30	70	35	Rock.....	-30	Manufactur- ing.	28
...do	Ample...	Hard	Sewage...	...do	40	60	45	Gravel ...	-30	None	29
.....	...do	Soft	None .....	...do	30	70	35	Clay.....	-30	Steam	30
.....	...do .....	...do .....	...do .....	...do	40	50	45	Rock.....	-15	.....	31
Ind i- vidual.	...do .....	...do .....	...do .....	...do	30	35	35	Sand.....	-30	None	32
City	Insuffi- cient.	...do .....	...do .....	...do	800	900	900	.....	-21	.....	33
.....	.....	Hard .....	...do	Other w'ls	12	15	12	Clay.....	-4	Steam boiler.	34
.....	Ample...	Soft	None	None	10	20	20	Sand ...	.....	Railroad.....	35
Ind i- vidual.	...do .....	...do .....	...do .....	...do	20	40	30	...do	-20	Steam	36
...do	Insuffi- cient.	...do .....	...do .....	...do	35	150	35	.....	-20	Steam and manufac- turing.	37
City	Ample...	...do .....	...do .....	...do	40	60	.....	.....	.....	.....	38
Ind i- vidual.	Insuffi- cient.	.....	...do .....	...do	25	35	25	.....	.....	None	39
.....	.....	.....	.....	Deep well.	20	30	30	.....	-20	.....	40
Ind i- vidual.	Ample...	Soft	Seepage	None	10	15	15	Clay	-7	Milling and manufac- turing.	41
...do .....	...do .....	...do	None .....	...do	30	60	30	Gneiss ...	-20	None	42
City ....	...do .....	...do .....	...do .....	...do	30	40	30	Clay .....	.....	...do	43
Ind i- vidual.	.....	...do .....	...do .....	...do	20	80	35	.....	.....	...do	44
...do	Ample...	Hard .....	...do .....	...do	30	60	35	Lime- stone.	.....	...do	45

APPENDIX

Sources of water of

No.	County.	Locality.	Most common source.	Other sources.	Most satisfactory source.	Source of public supply.
46	Dade	Trenton	Wells.....	Springs.....	Wells.....	.....
47	Decatur	Attapulguis.....	do	do	do	Wells
48	do	Bainbridge	Artesian wells...	Shallow wells...	Artesian wells...	Artesian wells...
49	do	Brinson.....	Wells	None	Wells.....	Wells
50	do	Climax	do	do	do	do
51	do	Donelsonville....	do	do	do	do
52	do	Faceville	do	Springs.....	do	do
53	DeKalb	Clarkston	do	None	do	do
54	do	Decatur	do	do	do	do
55	Dodge	Eastman.....	Artesian Wells...	Shallow wells...	Artesian wells...	Artesian wells...
56	Dooley.....	Arabi	do	do	do	do
57	do	Pinehurst	Wells	Artesian wells...	do	do
58	do	Richwood.....	Artesian Wells...	Shallow wells...	do	do
59	do	Vienna	do	None	do	do
60	Dougherty...	Albany	do	Shallow wells...	do	do
61	Douglas	Douglasville....	Wells	Springs.....	Wells	Wells
62	Early	Blakely	Artesian Wells...	Shallow wells...	Artesian wells...	Artesian wells...
63	Elbert	Bowman.....	Wells	None	Wells	Wells
64	do	Elberton.....	do	do	do	do
65	Emanuel	Adrian	do	Artesian wells...	Artesian wells...	Artesian wells...
66	Emanuel	Summit.....	do	None	Wells	Wells
67	Fannin	Blueridge.....	do	Springs.....	do	do

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Georgia cities and towns.

Owner-ship.	Sufficiency of supply.	Quality.	Source of contamination.	New Supplies contemplated.	Range of depths of wells.		Depth to principal water supply.	Material in which water occurs.	Height of water above (+) or below (-) mouth of wells.	Special uses.	No.
					From -	To -					
.....	Insufficient.	Hard	None	None	22	60	.....	Limestone.	-18	None	46
Individual	.....	Soft	do	do	50	60	60	Sand.....	-30	do	47
City.....	Ample....	Hard	do	do	700	1,525	280	do	-50	Steam and manufacturing.	48
Individual	do	do	do	do	35	40	40	Rock.....	-20	Milling	49
do .....	.....	do	do	do	20	35	25	.....	.....	.....	50
do	Ample....	do .....	.....	do	35	45	40	Clay	-25	None	51
.....	.....	Soft .....	.....	.....	30	35	35	Sand.....	.....	Machinery....	52
Individual	Ample....	Hard	None	None	20	40	.....	Clay	-15	None	53
do	do	Soft	do	From Atlanta.	35	40	30	.....	.....	do	54
City	do	Hard	do	None	680	.....	680	Sand.....	-120	Manufacturing.	55
Individual	do	do	do	do	200	238	238	do .....	.....	Steam	56
.....	do	Soft	do	do	20	35	30	Clay .....	.....	.....	57
Individual	do	Hard	do	do	170	200	170	do	-40	None	58
Town	Insufficient.	do	do	do	180	200	180	Rock.....	-12	Manufacturing.	59
City	Ample....	Soft	do	do	300	1,500	.....	Sand.....	+30	Steam	60
.....	do	Hard	do	do	35	40	35	.....	.....	.....	61
City	do	Soft	do	do	250	812	812	Sand.....	-19	None	62
Individual	.....	Hard	do	do	30	35	35	.....	-25	do	63
do .....	.....	do	Seepage	Spring.....	12	150	80	Granite...	-10	Milling	64
.....	Ample....	Iron	None	None	300	350	300	Sand.....	-60	Milling and manufacturing.	65
Individual	.....	Hard	do	do	15	35	18	Clay .....	.....	.....	66
do	Insufficient.	Soft	do	Stream.....	20	70	30	Schist....	-20	Manufacturing.	67

Sources of water of

No.	County.	Locality.	Most common source.	Other sources.	Most satisfactory source.	Source of public supply.
68	Floyd.....	Cavesprings....	Springs.....	Wells.....	Springs.....	Springs.....
69	do.....	Lindale.....	do.....	Stream.....	do.....	do.....
70	Franklin.....	Carnesville.....	Wells.....	None.....	Wells.....	Wells.....
71	Fulton.....	Atlanta.....	River.....	Wells, springs..	River.....	River.....
72	do.....	Hapeville.....	Wells.....	Springs.....	Wells.....	Wells.....
73	Gilmer.....	Ellijay.....	do.....	do.....	Springs.....	do.....
74	Glynn.....	Brunswick.....	Artesian wells..	Shallow wells..	Artesian wells..	Artesian wells..
75	do.....	St. Simons.....	do.....	do.....	do.....	do.....
76	Gordon.....	Calhoun.....	Springs.....	do.....	Springs.....	Springs.....
77	do.....	Sugar Valley....	Wells.....	None.....	Wells.....	Wells.....
78	Greene.....	Penfield.....	do.....	Springs.....	do.....	do.....
79	do.....	Unionpoint.....	do.....	None.....	do.....	do.....
80	do.....	Whiteplains.....	do.....	Springs.....	do.....	do.....
81	Gwinnett.....	Buford.....	do.....	None.....	do.....	do.....
82	do.....	Duluth.....	do.....	do.....	do.....	do.....
83	do.....	Sewanee.....	do.....	Springs, creeks	do.....	do.....
84	Habersham.....	Clarksville....	do.....	Springs.....	do.....	do.....
85	do.....	Cornelia.....	do.....	do.....	do.....	do.....
86	do.....	Toccoa.....	do.....	do.....	do.....	do.....
87	Hall.....	Belton.....	do.....	Springs.....	do.....	do.....
88	Haralson.....	Bremen.....	do.....	do.....	do.....	do.....
89	do.....	Tallapoosa.....	Creeks.....	None.....	Creeks.....	Creeks.....
90	do.....	Waco.....	Wells.....	do.....	Wells.....	Wells.....

Georgia cities and towns

Own- ership.	Suffi- ciency of supply.	Quality.	Source of Contami- nation.	New supplies contem- plated.	Range of depths of wells.		Depth to principal wa- ter supply.	Material in which water occurs.	Height of water above (+) or below (-) mouth of wells.	Special uses.	No.
					From—	To—					
Indi- vidual.	Ample ..	Hard....	None	None	20	40	30	Clay	-20	Manufac- turing.	68
Town..	...do....	...do....	...do....	...do....	40	60	45	Lime- stone	-30	None	69
Indi- vidual.	...do....	Alkaline	...do....	...do....	40	50	30	Mica schist...	-30	...do....	70
City ..	...do....	Soft .....	...do....	...do....	25 300	50 2800	30	Gneiss ..	-30	Manufac- turing.	71
Indi- vidual.	...do....	...do....	...do....	...do....	25	30	25	Gneiss...	-15	None	72
...do...	Ample...	...do....	Drainage	Stream....	20	35	25	...do....	-18	...do....	73
...do...	...do....	Hard....	None	None	350	460	460	Sand	+28	Manufac- turing.	74
Mills...	...do....	...do....	...do....	...do....	.....	.....	465	.....	+32	Boiler	75
...do...	...do....	...do....	...do....	...do....	20	30	20	Clay.....	-20	Manufac- turing.	76
Indi- vidual.	...do....	...do....	...do....	...do....	30	35	25	Lime- stone.	-20	Machinery..	77
...do...	...do....	Soft .....	...do....	...do....	40	70	50	Rock...	-15	Manufac- turing.	78
...do...	...do....	do.....	...do....	...do....	20	50	35	Clay.....	-30	...do....	79
...do...	...do....	Hard....	...do....	.....	22	40	60	...do....	-30	.....	80
...do...	Insuffi- cient.	Soft .....	...do....	None	40	50	40	Rock	-20	Factory.....	81
...do...	Ample ..	...do....	...do....	...do....	34	65	39	.....	.....	None	82
...do...	...do....	Iron .....	...do....	...do....	35	55	40	Clay .....	.....	Engines	83
...do...	...do....	Soft	Drainage	...do....	30	35	35	...do....	-20	None	84
...do...	Insuffi- cient.	...do....	None	Water- works.	40	60	20	.....	.....	...do....	85
...do...	Ample ..	Iron.....	do.....	None	30	33	35	Rock	-30	Factory.....	86
...do...	.....	Soft	do.....	...do....	15	60	35	Clay	-15	None	87
...do...	Insuffi- cient.	.....	...do....	...do....	30	50	20	...do....	-20	Machinery ..	88
Town..	Ample...	Soft .....	...do....	...do....	20	40	30	.....	-20	.....	89
...do...	...do....	Hard....	...do....	...do....	40	45	40	Clay	-25	Steam.....	90

Sources of water of

No.	County.	Locality.	Most common source.	Other sources.	Most satisfactory source.	Source of public supply.
91	Harris.....	Hamilton.....	Wells.....	Springs.....	Wells.....	Wells.....
92	.....do.....	Waverly Hall.....	.....do.....	None.....	.....do.....	.....do.....
93	Hart.....	Bowersville.....	.....do.....	.....do.....	.....do.....	.....do.....
94	Heard.....	Franklin.....	.....do.....	Springs.....	.....do.....	.....do.....
95	Henry.....	Hampton.....	.....do.....	None.....	.....do.....	.....do.....
96	.....do.....	Locustgrove.....	.....do.....	.....do.....	.....do.....	.....do.....
97	Houston.....	Byron.....	.....do.....	Artesian wells.....	.....do.....	.....do.....
98	.....do.....	Fort Valley.....	Springs.....	None.....	Springs.....	Springs.....
99	.....do.....	Perry.....	Wells.....	Artesian wells..... Streams.....	Wells.....	Wells.....
100	Houston.....	Powersville.....	Wells.....	Streams.....	Stream.....	.....
101	Irwin.....	Fitzgerald.....	Artesian wells.....	Shallow wells.....	Artesian wells.....	Artesian wells.....
102	.....do.....	Ocdilla.....	Wells.....	Lakes.....	Wells.....	Wells.....
103	Jackson.....	Harmony Grove.....	.....do.....	.....do.....	.....do.....	.....do.....
104	.....do.....	Maysville.....	.....do.....	None.....	.....do.....	.....do.....
105	.....do.....	Pendergrass.....	.....do.....	.....do.....	.....do.....	.....do.....
106	.....do.....	Winder.....	.....do.....	.....do.....	.....do.....	.....do.....
107	Jefferson.....	Avera.....	.....do.....	.....do.....	.....do.....	.....do.....
108	.....do.....	Bartow.....	Artesian wells.....	Shallow wells.....	Artesian wells.....	Artesian wells.....
109	.....do.....	Louisville.....	Wells.....	Artesian wells.....	Wells.....	Wells.....
110	.....do.....	Wadley.....	Artesian wells.....	Shallow wells.....	Artesian wells.....	Artesian wells.....
111	Laurens.....	Dublin.....	.....do.....	.....do.....	.....do.....	.....do.....
112	Lee.....	Smithville.....	Wells.....	None.....	Wells.....	Wells.....
113	Liberty.....	Dorchester.....	.....do.....	.....do.....	.....do.....	.....do.....

Georgia cities and towns.

Ownership.	Sufficiency of supply.	Quality.	Source of contamination.	New supplies contemplated.	Range of depths of wells.		Depth to principal water supply.	Material in which water occurs.	Height of water above (+) or below (-) mouth of wells.	Special uses.	No.
					From	To					
Individual.	Ample.	Soft	None.	None.	30	60	30	Gneiss.	-20	None	91
do.	do.	do.	do.	do.	25	30	25	Clay	-25	Ginning	92
do.	do.	Iron.	do.	do.	30	35	30	do.	-10	None	93
do.	do.	Soft	do.	do.	40	50	30	do.		Ginning.	94
do.	do.	do.	do.	do.	20	45	30	do.	-15	None	95
Individual.	Ample.	do.	do.	do.	30	40	30	do.		do.	96
do.	Insufficient.	Hard.	do.	do.	30	100	50	Sand	-20	Ginning	97
City.	Ample	do.	do.	do.	15	50		do.		Manufacturing.	98
Individual.	Insufficient.	Soft	Seepage.	do.	50	60	55	do.	-30	None	99
do.	do.	Soft	None.	None	10	50	30	Sand		Railroad	100
City	Ample.	Hard.	do.	do.	140	680	680	Rock	-40	Manufacturing.	101
Individual.	Insufficient.	do.	do.	do.	25	30	25	do.	-30	None	102
do.	do.	Soft	Surface drainage.	do.	50	60	55	do.	-55	do.	103
do.	do.	Hard	do.	do.	30	50	35	Sand	-20	Machinery	104
do.	do.	Soft	None	do.	30	50	35	Rock		None	105
do.	do.	Hard.	do.	Water-works.	18	45	25	do.		Machinery	106
do.	Ample.	Soft	do.	None	40	50	40	Sand		None	107
do.	do.	Hard.	do.	do.				do.		Manufacturing.	108
do.	do.	Soft	do.	do.	{ 350 30	{ 450 70	{ 250 35	do.	-30	None	109
do.	do.	Hard.	do.	do.	15	50	15	Clay			110
do.	do.	do.	do.	do.	185	225	250	Sand	-30	Manufacturing.	111
do.	do.	do.	Drainage	Artesian well	20	40			-20		112
do.	do.	Soft			20	30	25	Sand			113

Sources of water of

No.	County.	Locality.	Most common source.	Other sources.	Most satisfactory source.	Source of public supply.
114	Liberty	Hinesville	Driven wells	Springs	Driven wells	Driven wells
115	Lowndes....	Valdosta	Artesian wells...	Shallow wells.	Artesian wells...	Artesian wells...
116	Macon	Marshallville	do	do	do	do
117	do	Montezuma	do	do	do	do
118	Madison	Carleton	Wells	None	Wells	Wells
119	Meriwether	Woodbury	do	do	do	do
120	Mitchell	Palham	do	do	do	do
121	Monroe	Forsyth	Waterworks	Wells	Waterworks	Waterworks
122	Montgomery	Longpond	Wells	None	Wells	Wells
123	Morgan	Rutledge	do	do	do	do
124	Muscogee	Columbus	River	Wells	River	River
125	Newton	Covington	Wells	None	Wells	Wells
126	do	Newborn	do	do	do	do
127	Oglethorpe	Lexington	do	Ponds	do	do
128	Paulding	Dallas	do	Springs	do	do
129	Pickens	Marblehill	Springs	None	Springs	Springs
130	do	Nelson	Streams	Wells	Streams	Streams
131	Pierce	Blackhear	Wells	None	Wells	Wells
132	Pike	Barnesville	Springs	do	Springs	Springs
133	do	Concord	Wells	do	Wells	Wells
134	do	Milner	do	do	do	do
135	Polk	Cedartown	Springs	Wells	Springs	Springs
136	do	Rockmart	Wells	Springs	Wells	Wells
137	Putnam	Eatonton	Streams	Wells	do	do

Georgia cities and towns.

Owner- ship	Suffi- ciency of supply.	Quality.	Source of contami- nation.	New supplies contem- plated.	Range of depths of wells.		Depth to principal wa- ter supply.	Material in which water occurs.	Height of water above (+) or below (-) mouth of well.	Special uses.	No.
					From—	To—					
Town...	Ample...	Iron...	None	None	10	20	14	Sand .....	.....		114
.. do...	.. do...	Hard...	.. do...	.. do...	300	500	200	Lime- stone.	-113		115
.. do...	.. do...	.. do...	.. do...	.. do...	397	.....	397	Sand	-121		116
.. do...	.. do...	.. do...	.. do...	.. do...	60	500	.....	.. do...	+62		117
Indi- vidual.	.. do...	.. do...	.. do...	.. do...	25	30	20	.....			118
.. do...	.. do...	.. do...	None .....	.. do...	25	30	30	Clay			119
.. do...	.. do...	.. do...	.. do...	Deep well	20	50	25	.....			120
City...	Ample...	Soft .....	.. do...	None	40	50	40	Clay	-30		121
.. do...	.. do...	.. do...	.. do...	.. do...	30	50	.....	.....			122
.. do...	Ample...	Hard...	.. do...	.. do...	25	50	30	Schist..	-20	None ..	123
Indi- vidual.	.. do...	Soft	None	Spring...	20	30	25	Sand	-15	Manufac- turing.	124
.. do...	.. do...	.. do...	.. do...	Water- works.	.....	35	35	Granite..	-15	Ginning.....	125
.. do...	Insuffi- cient	.. do...	.. do...	None	40	60	40	Clay	-30	None	126
.. do...	.. do...	.. do...	.. do...	.. do...	.....	20	30	Granite..	-20	.. do	127
.. do...	Ample...	Soft	None	None	25	50	35	.....		.. do	128
.. do...	.. do...	.. do...	.. do...	.. do...	.....	.....	.....	.....			129
.. do...	.. do...	Soft	None	None	50	100	30	Mica schist.	-20	Milling	130
.. do...	.. do...	Hard...	.. do...	Artesian well.	15	65	65	Clay	-20	None	131
Town...	.. do...	.. do...	None	None	20	35	25	.. do...	-20	Manufac- turing.	132
Indi- vidual.	.. do...	Soft .....	.. do...	.. do...	25	30	25	.. do...	-25	None	133
.. do...	.. do...	.. do...	.. do...	.. do...	15	30	20	.. do...	-12	Ginning.....	134
City...	Ample...	Hard	None	None	20	40	30	Clay	-30	Manufac- turing.	135
Indi- vidual.	.. do...	.. do...	.. do...	.. do...	20	120	30	Lime- stone.	-15	None	136
.. do...	.. do...	Soft .....	.. do...	.. do...	35	60	40	Sand .....	.....	.. do	137

Sources of water of

No.	County.	Locality.	Most common source.	Other sources.	Most satisfactory source.	Source of public supply.
138	Randolph...	Coleman	Wells	Springs	Wells	Wells
139	..... do	Shellman	Artesian wells...	Shallow wells ..	..... do .....	..... do
140	Richmond...	Augusta	River	Wells	River	River
141	Schley	Ellaville	Wells	None	Wells	Wells
142	Screven	Oliver .....	.....do	Driven wells...	Driven wells....	Driven wells ...
143	.... do	Rockyford	Artesian wells...	Surface wells...	Artesian wells...	Artesian wells...
144	Stewart	Lumpkin	Springs	Wells	Springs	Springs
145	..... do	Omaha	Wells	Springs	Wells	Wells
146	Sumter	Americus	Artesian wells...	Shallow wells...	Artesian wells...	Artesian wells...
147	..... do	Andersonville ..	Bored wells	Springs	Wells	Wells
148	..... do	DeSoto	Artesian wells...	Shallow wells...	Artesian wells...	Artesian wells...
149	..... do	Plains	Wells	None	Wells	Wells
150	Taliaferro ..	Crawfordville...	.....do	Springs .....	.....do .....	.....do
151	..... do	Nye .....	.....do	None .....	..... do .....	... do
152	..... do	Sharon .....	.....do .....	..... do .....	..... do .....	..... do
153	Tattnall	Claxton .....	.....do	Driven wells ..	.....do	Driven wells
154	..... do	Glenville .....	.....do .....	..... do .....	..... do	Wells
155	..... do	Hagan .....	.....do .....	..... do .....	.....do	Driven wells
156	..... do	Reidsville .....	..... do	None .....	.....do	Wells
157	Taylor	Butler .....	.....do .....	..... do .....	..... do .....	..... do
158	Terrell	Bronwood	Artesian wells...	Shallow wells...	Shallow wells ...	Shallow wells ...
159	Thomas	Boston .....	.....do .....	..... do	Artesian wells...	Artesian wells...
160 do	Cairo	Wells	None	Wells	Wells
161	... do	Chastaindo dododo
162 do	Maigsdo dododo

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Georgia cities and towns.

Owner-ship.	Sufficiency of supply.	Quality.	Source of contamination.	New supplies contemplated.	Range of depths of wells.		Depth to principal water supply.	Material in which water occurs.	Height of water above (+) or below (-) mouth of wells.	Special uses.	No.
					From—	To—					
Individual	Ample...	Soft	None	None	40	60	40	Sand....	.....	None	138
Town...	do	Sulphur	do	do	40	50	40	do .....	.....	Ginning	139
do	do	Soft	do	do	30	70	40	do	-20	Manufacturing.	140
do	do	do	do	do	30	70	60	do .....	.....	None	141
Individual	Ample...	do	None	do	20	25	24	do	-8	do	142
do	do	do	do	do	150	200	187	do .....	.....	do	143
Town...	do	do	do	do	50	60	60	do	-35	do	144
Individual	do	do	do	do	30	50	40	Gravel .....	.....	do	145
City	do	Hard	do	None	400	1,725	400	Sand	-20	Steam	146
Individual	do	Soft	do	do	40	70	65	do .....	.....	Boiler purposes.	147
do	do	do	do	do	250	265	265	Rock	-13	None	148
do	do	do	do	do	25	50	50	Sand .....	.....	do	149
Individual	do	do	do	do	35	40	25	Clay	-25	Engines	150
do	do	Hard	do	do	28	36	30	Sand .....	.....	None	151
do	do	Soft	do	do	22	26	25	Clay .....	.....	do	152
do	Insufficient.	do	Drainage	do	20	25	25	do .....	.....	do	153
do	Ample...	do	None	Artesian well.	20	30	20	do .....	.....	do	154
do	do	Hard	do	do	14	18	18	do .....	.....	do	155
do	Insufficient.	Soft	do	Artesian well.	18	20	18	do	-6	None	156
do	Ample...	do	do	None	30	90	40	Sand	-30	do	157
do	Insufficient.	do	do	do	30	60	30	Rock	-85	Machinery	158
Town...	Ample...	Hard	do	do	290	.....	286	Lime-stone.	-128	Manufacturing.	159
Individual	do	Soft	do	do	25	40	25	do .....	.....	do	160
do	Ample...	do	do	do .....	.....	.....	.....	do .....	.....	do	161
do	do	do	do	None	20	30	20	Sand	-20	None	162

Sources of water of

No.	County	Locality	Most common source	Other sources	Most satisfactory source	Source of public supply
163	Thomas	Ochlochnee	Wells	None	Wells	Wells
164	Towns	Hiawasse	do	do	do	do
165	do	Young Harris	do	Springs	do	do
166	Troup	Mountville	do	None	do	do
167	do	Westpoint	River	Cisterns	River	River
168	Upson	Thomaston	Wells	None	Wells	Wells
169	do	Yatesville	do			
170	Walker	Cedargrove	Springs	Wells	Springs	Springs
171	Walker	Lafayette	Wells		Wells	Wells
172	Walton	Monroe	do	None	do	do
173	Ware	Wareboro	do	do	do	do
174	Warren	Barnett	do	Springs	do	do
175	Wash'gton	Harrison	do	None	do	do
176	do	Sandersville	do			
177	Wayne	Jesup	do	Artesian wells	Artesian wells	Wells
178	do	Waynesville	do	Springs	do	do
179	Whitfield	Dalton	Springs	Wells	Springs	Springs
180	do	Tilton	Wells	None	Wells	Wells
181	Wilcox	Abbeville	Artesian wells	Shallow wells	Artesian wells	Artesian wells
182	do	Seville	Wells	Artesian wells		
183	Worth	Ashburn	do	None	Wells	Wells
184	do	Wilmington	do	do	do	do

Georgia cities and towns.

Owner- ship	Suffi- ciency of supply	Quality	Source of contami- nation	New supplies contem- plated	Range of depths of wells		Depth to principal wa- ter supply	Material in which water occurs	Height of water above (+) or below (-) mouth of wells	Special uses	No.
					From—	To—					
Indi- vidual	.....	Soft	None	None	Ft. 20	Ft. 40	20	Clay	Ft. ....	.....	163
.. do ..	Insuffi- cient.	Iron .....	...do .....	.. do ..	30	35	35	.....	-20	None	164
.. do ..	..do	Soft .....	.....	...do	30	50	35	Gravel ..	-30	.... do	165
.. do ..	.....	Hard .	None .....	...do ..	20	70	35	Rock .....	.....	.... do	166
Town ..	Ample...	Soft .....	...do ..	... do ..	.....	.....	.....	.....	.....	Manufactur- ing.	167
Indi- vidual	.....	Hard ,	...do ..	...do ..	20	50	25	.....	.....	None	168
.....	.....	Soft .....	...do ..	...do ..	25	35	30	.....	-20	.... do	169
.....	Ample...	Hard .....	...do ..	... do ..	20	30	20	Rock .....	.....	.....	170
.....	Ample...	Hard	None	None	30	33	30	Clay .	.....	None	171
Indi- vidual	.....	Soft	Drainage	Water- works.	30	70	35	.... do ..	-30	.... do	172
.. do ..	Ample...	.....	None	None	12	30	15	.... do ..	-20	.... ..	173
.. do ..	.. do ..	.....	.....	.....	40	50	.....	.....	.....	.....	174
.. do ..	.....	Soft .....	.....	None	25	35	25	.....	.....	None	175
.....	.....	...do ..	.....	Artesian well.	30	60	45	Sand	-35	.....	176
Indi- vidual	Ample...	Hard .....	.....	None ..	25	35	30	.... do ..	-20	None	177
.. do ..	.. do ..	.....	Drainage	.... do ..	15	20	15	Clay ..	.....	.....	178
City ..	...do ..	Hard	None .....	.... do ..	20	40	25	.... do ..	-20	Manufac- turing.	179
Indi- vidual	.....	...do ..	.... do ..	.... do ..	30	40	30	Sand	-5	None	180
.....	Ample...	...do ..	.... do ..	.... do ..	20	40	30	.... do ..	-25	Steam	181
.....	.. do ..	...do ..	.... do ..	.... do ..	25	30	25	Clay	-8	Ginning	182
Indi- vidual	.....	Soft .....	.....	.... do ..	20	30	20	.... do ..	.....	None	183
.. do ..	.....	.....	None ..	do ..	10	100	.....	.....	.....	Milling	184

APPENDIX B

MISCELLANEOUS SPRING RECORD

Springs are very numerous and sometimes of considerable size in the northwestern Paleozoic belt of rocks, especially in the limestone areas, where subterranean streams are of not uncommon occurrence. In the crystalline area the springs result from the emergence of seepage waters from the weathered rocks. They are very numerous and evenly distributed, but are small in size. In the Coastal Plain belt the springs are not of so common occurrence, but as the coast is approached numerous springs emerge from the porous limestone or other beds. Some of these are of very large size, giving rise to strong streams at the very start.

Miscellaneous spring

No	County	Locality	Owner	Odor	Taste	Sediment	Mineral deposit	Quality
1	Bartow...	Cartersville...	Bartow Manganese and Mining Co.	None	Iron	None	None	Iron
1a	do	Hall	J. C. Karr	do	do	do	do	do
2	do	Barnesley		do	do	do	do	do
2a	Campbell	Fairburn	Henry Roan	do	do	do	Iron	do
3	do	do	W. Y. Wright	do	None	do	None	Soft
4	Catoosa	Beaumont	W. P. Henry	do	do	do	do	do
5	do	Catoosa Springs	General Baldwin	do	Saline	do	do	Saline
6	do	do	do	do	None	do	do	Hard
7	do	do	do	do	Saline	do	do	do
8	do	do	do	do	do	do	do	do
9	do	Ringgold	W. T. Parks	do	None	do	do	Soft
10	do	Wilnot	B. S. Dills	Sulphur	Iron	Iron	Sulphur	Iron, Sulphur
11	Chattooga	Menlo		None	do	do	Iron	Iron
12	do	Summerville	J. S. Cleghorn	do	None	None		Hard
13	do	do	T. R. Knox	do	do			do
14	Cobb	Marietta	D. F. McClatchey	do	do	None	None	Soft
15	do	Powder Springs	J. W. Morrow	Sulphur	Sulphur	do	do	Sulphur
16	Coffee	Douglas	Gaskins	None	None	do	do	
17	do	do			Bad			Sulphur
18	Colquitt	Cool Springs	Cool Springs Church	Sulphur	None	None		
19	Dade	Trenton	— Case	None	Sulphur	Yes	Sulphur	Sulphur
20	Decatur	Calvary	J. F. Dorsey	do	None	do		Soft
20a	do	Near Bainbridge	Russell	do	do	do		Hard
21	do	Cinax	W. E. Powell	do	Iron	do	Iron	
22	do	Whigham	Whigham	do	None	None	None	Soft
23	do	do	do	do	do	do	do	do
24	Dooly	Cordele	Cordele	do	do	do	do	Hard
25	Dougherty	Albany	Unknown	do	do	do	do	do

¹ These spring records were first published by the U. S. Geological

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records of Georgia.¹

Principal mineral or gaseous constituents	Supply per minute	Manner of emergence	Material from which spring issues	Age of material from which spring issues	Uses	Improvements	No
Iron	Galls. 5	Stream.	Granite.....		Medicinal.....	None.....	1
	Many	do	Limestone.....				1a
	Many.	do	do				2
do	1	do	Gneiss.....		do	do	2a
	75	do			None	do	3
	2,000	do	Limestone.....	Silurian.....	Milling and domestic.	do	4
Magnesia	½	do	Black shale.....	Cambrian.....	Medicinal.....	Hotel.....	5
do	2	do	do	do	do	do	6
do	2	do	do	do	do	do	7
do	3	do	Shale.....	do	do	do	8
Lime	100	do	Limestone.....	Silurian (?)	Milling.....	None.....	9
Iron		do	Shale.....	Silurian.....	Domestic.....	do	10
do	1	do	Black shale.....	Devonian.....	Medicinal.....	Hotel.....	11
Lime carbonate	1,000	do	Limestone.....	Cambrian.....	None.....	None.....	12
do	2,000	do	do	do	Domestic.....	do	13
		do	Mica schists.....		Medicinal.....	do	14
Sodium chloride,	Few	Seepage.	Schist.....	Unknown.....	do	do	15
	Many.	do	Alluvial.....	Tertiary.....	Drinking, bathing.	Bath house, etc.	16
		Stream.			Drinking.....	None.....	17
		do		Tertiary.....	do	do	18
	Few.	Seepage.	Limestone.....	Silurian.....	Medicinal.....	Hotel.....	19
		Stream.	Clay.....	Tertiary.....	Runs hydraulic engine.	None.....	20
	Many.	do	do	do			20a
		do	Sand.....	do	Medicinal.....	do	21
	1	do	Clay.....	Eocene.....	Domestic.....	do	22
	3	do	do	Tertiary.....	Drinking.....	do	23
Limestone	Many.	do	Limestone.....	Oligocene.....	Domestic.....	do	24
Calcium	50,000	do	do	do	None.....	do	25

Survey, Water-Supply and Irrigation Paper 102, 1904.

Miscellaneous spring

No	County	Locality	Owner	Odor	Taste	Sedi- ment	Mineral deposit	Quality
26	Douglas.....	Lithia Springs...	E. W. Marsh estate	None	Saline.....	None	None	Saline
27	Floyd.....	Armuchee	J. F. Martin.....	do	None	do	do	Hard
28	do	Cavesprings.....	Cavesprings	do	do	do	do	do
29	do	Coccosville.....	Mitchell Cooper.....	do	do	Some	None	do
30	do	Floyd Springs	Mrs. E. T. Morris- son.	do	do	Small	Iron.....	Iron, Sul- phur.
31	do	Lindale	T. H. Boose.....	do	Iron.....	None	None	Hard
32	do	Near Rome.....	Mrs. Battey.....	do	None	do	do	do
33	do	do	Mrs. M. E. Hunt	do	do	do	do	Soft
34	do	do	G. J. Bryant.....	do	do	do	do	Hard
35	do	Near Rome.....	Alex Johnstone.....	do	do	None	None	do
36	do	do	J. H. Reese.....	do	do	do	do	do
37	do	do	Alex Smith.....	do	do	do	do	do
38	do	do	J. P. Tippens.....	do	do	None	do	do
39	do	do	do	do	do	do	do	do
40	do	do	do	do	do	do	do	Soft
41	Fulton.....	Near Atlanta.....	W. M. Dockins	do	do	None	None	do
42	do	Atlanta, Ponce De Leon.	Atlanta.....	None	None	Iron	Iron	Iron
43	do	Atlanta, Inman Park.	Atlanta.....	do	do	None	do	do
44	do	Near Atlanta.....	do	do	do	do	None	do
45	do	do	Atlanta Mineral Water Co.	do	do	do	do	Soft
46	Gilmer.....	Whitepath.....	J. M. Dorn.....	do	Iron	Iron	Iron	Iron
47	Gordon.....	Cash.....	— Dew.....	do	None	None	None	Hard
48	Hall	Bowdre.....	do	Sulphur	Sulphur	Yes	Sulphur	Sulphur
49	do	Gainesville	J. W. Oslin.....	None	None	Iron	Iron	Iron
50	do	do	Pascolet Manufac- turing Co.	do	do	None	None	Hard
51	Harris.....	Westpoint.....	J. C. Blanton.....	do	do	do	Iron	Soft
52	Lumpkin.....	Dahlonega.....	W. P. Price.....	do	do	do	do	Iron
53	do	do	H. E. Underwood.....	do	do	Small	Yes	Soft

records of Georgia.

Principal mineral or gaseous constituents	Supply per minute	Manner of emergence	Material from which spring issues	Age of material from which spring issues	Uses	Improvements	No
Sodium chloride.....		Stream	Gneiss.....	Unknown.....	Medicinal.....	Hotel, etc.....	26
Lime carbonate.....	Many.	do	Limestone.....		Domestic.....		27
do.....	20	do	do	Cambrian.....	Drinking.....	None.....	28
do.....		do			Domestic.....	do	29
Iron.....		do		Cambrian.....	None.....	do	30
Limestone.....	Many.	do	Limestone.....	do		do	31
do.....	do	do	do	do	None.....	do	32
do.....	do	do		do	do	do	33
Lime.....	do	do	Limestone.....	do		do	34
Lime carbonate.....	7	do	Rock.....	do	Domestic.....	do	35
Lime.....	Many.	do	Limestone.....	do		do	36
do.....	do	do	do	do		do	37
do.....	do	do	do	do		do	38
do.....	do	do	do	do			39
do.....		do	do	Unknown.....			40
Silica.....	Sev'l.	do	Granite.....	do	Domestic.....	None.....	41
Iron.....	1	Seepage..	Gneiss.....	Unknown.....	Medicinal.....	do	42
do.....	1	do	do	do	do	do	43
do.....	1/4	do	do	do	do	do	44
None.....	3	Stream	do	do	do	do	45
do.....	Many..	do	Slates.....	Cambrian(?)..	do	Hotel, etc.....	46
Lime Carbonate.....	7,200	do	Limestone.....	Unknown.....	Milling.....	None.....	47
Hydrogen, Sulphide.....	Few		Schists.....	do	Medicinal.....	Hotel.....	48
Iron.....	Few	Seepage..	do	do	do	None.....	49
None.....	Many	Stream	do		Domestic.....	do	50
do.....	500	do	Gravel.....		Milling, drinking.....	do	51
Iron.....		Seepage..	Schists.....	Unknown.....	Medicinal.....	do	52
do.....		Stream	do	do	Domestic.....	do	53

Miscellaneous spring

No	County	Locality	Owner	Odor	Taste	Sedi- ment	Mineral Deposit	Quality
54	Lumpkin...	Porter Springs..	Mrs. Carrie Farrow	None	None	None	None	Iron
55	Meriwether.	Bullochville	United States fish- ery	do	do			Soft
56	do	Warm Springs...	Chas. Davis.	do	do			Hard
57	Murray	Carters	S. M. Carter's es- tate.	do	Lime			do
58	do	Cohutta Springs	H. D. Huffaker.	do	Iron	Iron	Iron	Iron
59	do	do		do	do	do	do	do
60	do	Fort Mountain...	Mrs. Staril.	do	None	do	do	do
61	do	Springplace	C. A. King.	do	Lime	None	None	Alkaline.
62	do	do	A. L. Keith.	do	do	do		Hard
63	Polk.....	Aragon	Aragon Mill	do	None	do	None	do
64	do	Cedartown.....	— Dodd.....	do	do	do	do	do
65	do	do	— Green.....	do	do	do	do	do
66	do	do	— Peek	do	do	do	do	do
67	do	do	J. H. Philpot	do	do	do	do	do
68	do	do	W. R. Ray		Sulphur.	Some	Some	do
69	do	do	J. O. Waddell.....	None.	None	None	None	do
70	do	do	— West.....	do	do	do	do	do
71	do	Pasco.....	N. Cochran.....	do	Lime.....	do	do	do
72	do	Rockmart.....	R. W. Everett.....	do	None	do	do	do
73	do	do	Mrs. Jones.....	do	do	do	do	do
74	do	do	G. W. Morgan.....	do	do	do		Iron
75	do	do	Porter Jones.....	do	do	do	None	Hard
76	do	do		do	do	do	do	do
77	Sumter.....	Americus.....	C. A. Chambliss...	do	do	do	do	Hard (?)..
78	do	do	Lee Hansford.....	do	do	do	do	Hard
79	do	Lealia	J. M. Summerford..	do	do	do	do	do
80	Thomas.....	Meigs	C. E. Alligood.....	do	do	do	do	Soft

APPENDIX

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records of Georgia.

Principal mineral or gaseous constituents.	Supply per minute.	Manner of emergence.	Material from which spring issues.	Age of material from which spring issues.	Uses.	Improvements.	No.
	<i>Galls</i>						
	2	Stream	Schists	Unknown	Drinking, bathing.	Hotel for 125 guests.	54
Silica	2,025	do	Quartzite	do	United States fishery.	Various	55
Lime	1,390	do	do	do	Bathing	Large hotel, etc.	56
Lime carbonate.		do	Limestone	Silurian	Drinking	None	57
Iron	1/2	do	Black shale	Algonkian(?)	Medicinal	Small hotel	58
do	1/2	do	Shale	do	do	Cottages	59
do		do	Granite	Cambrian(?)	do	None	60
Lime carbonate.	100	do	Limestone(?)	Cambrian	Domestic	do	61
do	533	do	do		do	do	62
do	Many	do	do	Silurian	Drinking, washing and manufacturing.	do	63
do	Many	do	do	do	Domestic	do	64
do	do	do	do	do	do	do	65
do	300	do	do	do	None	do	66
do	10	do	do	Cambrian	Domestic	do	67
Lime	1,400	do	Gravel	Silurian	Medicinal	Cottages	68
do	Many	do	Limestone	do	None	None	66
do	do	do	do	Silurian(?)	Domestic	do	70
Lime carbonate.		do	do	Cambrian(?)	Drinking	do	71
do	do	do	do	Silurian(?)	None	do	72
Lime	do	do	do	Silurian	Domestic	do	73
do	do	do	do	do	None	do	74
Lime	do	do	Limestone	do	Domestic	do	75
do	do	do	do	do	do	do	76
	Many	do		Tertiary	do		77
	Many	do		do	do		78
Calcium carbonate.	Many	do	Sand	do	do	None	79
	100	do		do	Drinking		80

Miscellaneous spring

No	County	Locality	Owner	Odor	Taste	Sedi- ment	Mineral deposit	Quality
81	Thomas	Ochlochnee	Healde estate	Sulphur	Sulphur	None	None	Soft
82	Towns	Hiawassee	W. K. Heddon	None	None	do	do	do
83	do	do	do	do	do	do	do	do
84	do	Hunt	J. N. Gibson	do	do	do	do	do
85	Union	Blairsville	T. J. Irwin	do	do	do	do	do
86	do	do	Butts & Welborn	Sulphur	Pleasant	Yes	Iron	Soft, Sulphur
87	Upson	Molena	T. J. Willingham	None	None	None	None	Soft
88	do	Thunder	Z. Lawrence	do	do	do	do	do
89	Walker	Crawfish Spring	Gordon Lee	do	do	do	None	Hard
90	Warren	Wrightsboro	— Smith	do	do	do	do	Soft
91	Whitfield	Near Dalton	Olive A. Lukens	do	do	do	do	Hard
92	do	Cohutta	W. L. Williams	do	do	do	do	Soft (?)
93	do	Cove City	R. G. Houston	do	do	do	do	Hard
94	do	Dalton	Crown Cotton Mills	do	do	do	do	do
95	do	Near Dalton	Mrs. V. A. Hammond	do	do	do	do	do
96	do	Near Varnells	Mrs. Lulu Horn	do	do	do	do	do
97	do	Near Dalton	— Martin	do	Iron	do	Iron	Iron
98	do	McCutchen	W. H. Freeman	do	Lime	do	do	Hard
99	do	do	do	do	Sulphur	do	None	do
100	do	Tilton	Robert Nance	do	None	do	do	Soft

APPENDIX

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records of Georgia.

Principal mineral or gaseous constituents	Supply per minute	Manner of emergence	Material from which spring issues	Age of material from which spring issues	Uses	Improvements	No
.....	2	Stream	Sand	.....	Domestic	None	81
None	2	do	Schist	Unknown	Drinking	do	82
.....	1	do	Flint	do	do	do	83
.....		do	Rock	do	Domestic	do	84
.....	2	do		do	Drinking	do	85
.....		do	Schists	do	None	do	86
Carbon dioxide		do	Quartzite	do	do	do	87
do	50	do	do	do	Bathing	do	88
Calcium carbonate	10,400	do	Limestone	Cambrian	Domestic	Hotel	89
.....		do			do	None	90
Lime carbonate	11,000(?)	do	Limestone	Silurian	do	do	91
do	Many.	do	do	Silurian (?)	None	do	92
do	2,100	do	do	Silurian	Domestic	do	93
do	7,000	do	do	do	Domestic and manufacturing	Spring walled (rock)	94
do	1,000	do	do	Cambrian	Domestic	None	95
do	5,000	do		do	None	do	96
Iron	½	do	Black Shale	Devonian	Medicinal	do	97
Lime carbonate		do	Limestone	Cambrian (?)	None	do	98
Lime		do	do	Silurian (?)	do	do	99
do		do	do	Cambrian	do	do	100

APPENDIX C

LIST OF FOSSILS FROM THE COASTAL PLAIN OF GEORGIA

The following fossils identified chiefly by Dr. T. Wayland Vaughan, of the U. S. Geological Survey, were collected during 1904 and 1905 by the writer while engaged in studying the underground waters of the Coastal Plain of Georgia.

CRETACEOUS HORIZON

Locality.¹ — A cut on the public road near the Central of Georgia Railroad bridge, across Kinchafoonee Creek, 5 miles northwest of Buena Vista, Marion county.

Veniella.

Cardium dumosum Conr.

Locality.¹ — Lanneyhassey Creek, 4 miles south of Buena Vista, Marion County.

Exogyra costata Say.

Panopæa.

Locality.¹ — The Bivins plantation on Dry Creek, 3 miles west of Pineville, Marion county.

Exogyra costata Say.

Gryphæa vesicularis Lam.

Anomia argentaria Morton.

Paranomia saffordi Conr.

¹ These localities all appear to be the Ripley horizon.

Locality.¹ — A cut on the Columbus-Albany branch of the Seaboard Air Line Railroad, 16 mile-post, Chattahoochee county.

Exogyra costata Say,
principal fossil.
Chelonian plate.

Locality.¹ — A. D. Ray's farm on Hannahachee Creek, 7 miles northeast of Lumpkin, Stewart county.

Exogyra costata Say.
Gryphæa.

MIDWAY-SABINE HORIZON

Locality. — Flint river at the county bridge, 1 mile northwest of Montezuma, Macon county.

Turritella mortoni Conrad.
Ostrea crenulimarginata Gabb.

Locality. — Wall's Crossing, 4 miles west of Ellaville, Schley county.

Ostrea crenulimarginata Gabb.
Venericardia planicosta Lam.

Locality. — G. W. Cole's farm, 2 miles south of Preston, Webster county.

Ostrea crenulimarginata Gabb.

Locality. — J. F. Carter's farm, 1 mile southwest of Quebec, Schley county.

Ostrea crenulimarginata Gabb.

Locality. — A. D. Ray's farm on Hannahachee Creek, 6½ miles northeast of Lumpkin, Stewart county.

Turritella mortoni Conrad.
Venericardia planicosta Lam.

¹ These localities all appear to be the Ripley horizon.

Locality. — Green's Cave, near the Cuthbert-Lumpkin public road, 9 miles from Cuthbert, Randolph county.

Ostrea crenulimarginata Gabb.

Locality. — Edward Bell's farm, 2½ miles northeast of Preston, Webster county.

Impressions of —

Leda.

Nucula.

Venericardia, etc.

Locality. — On the Cuthbert-Lumpkin public road, 8 miles from Cuthbert, Randolph county.

Ostrea crenulimarginata Gabb.

Locality. — Prof. W. B. Merritt's farm, 4 miles northeast of Preston, near Bull's Mill, Webster county.

Ostrea thirsæ Gabb.

CLAIBORNE HORIZON

Locality. — The Fiskes' clay pit at Grovetown, Columbia county.

Turbinella (*Psilocochlis*) *mccalliei* Dall.

Ostrea.

Modiolus texanus Gabb.

Modiolus alabamiensis Aldrich?

Large pyruloid gastropod, n. sp.

Calyptraea aperta Solander.

Nucula magnifica Conrad.

Nucula ovula Lea.

Leda 2 sp.

Cytherea ovata var. *greggi* Harris.

Balanus sp.

Plants:¹ A Palm near to the living *Sabal adansonii*; *Castanea* resembling *Castanea dentata*; *Quercus* sp.? *Ficus* sp.?

¹ Determined by Dr. F. H. Knowlton.

Locality.—A clay pit, 1 mile south of Grovetown, Columbia county.
Arca, apparently cuculoides Conrad, small or young specimens.

Imprints of a pelecypod, suggestive of *Lucina greggi* Harris.

Locality. — W. G. Farver's farm, 6 miles south of Hephzibah, Richmond county.

Lutraria, like *lapidosa* Conrad.

Locality. — One mile northwest of Hephzibah, Richmond county.

Modiolus texanus Gabb.

Turbinella.

Locality. — A bluff on the Central of Georgia Railroad, Hollywood station, Richmond county.

Crepidula lirata Conrad.

Venericardia planicosta Lam.

Locality.¹ — Waynesville-Augusta public road, 1½ miles south of McBean's station, Richmond county.

Diplodonta sp.

Corbula densata Conrad.

Mesalia vetusta Conrad.

Bulla sp.

Locality.¹ — One-fourth mile south of McBean's station, Richmond county.

Pteropsis lapidosa Conrad.

Ostrea sellæformis Conrad.

Mesalia vetusta Conrad.

Crassatellites.

Modiolus.

Tellina.

Dentalium.

Corbula densata Conrad.

¹ Fossils identified by Dr. W. H. Dall.

Locality.¹ — Two miles north of Waynesboro, Burke county, near Central of Georgia Railroad.

Scutella sp., *Lucina* sp., *Spondylus* sp.

Mæginella sp., and *Mesalia vetusta* Conrad.

Locality. — Griffins Landing, Savannah River, Screven county.

Ostrea georgiana Conrad.

Locality. — The English plantation, 1½ miles north of Gibson, Glascock county.

Flabellum cuneiforme Lonsdale.

Endopachys maclurei Lea.

Mazzalina inaurata Conrad.

Pecten willcoxi Dall.

Venericardia planicosta Lam.

Venericardia alticostata Conrad.

Panopæa aff. *oblongata* Conrad.

Locality. — The Hannah property, 1¼ miles northeast of Gibson, Glascock county.

Venericardia planicosta Lam.

Corbula alabamiensis Lea.

Locality. — The Gibson-Mitchell public road, 200 yards west of Jumping Gulley Branch, Glascock county.

Flabellum cuneiforme Lonsdale.

Turritella carinata Lea.

Mesalia vetusta Conrad?

Locality. — Frank Pitman's property, 3 miles south of Avera, Jefferson county.

Flabellum cuneiforme Lonsdale.

Turritella aff. *carinata* Lea.

Mesalia sp.

Calyptraea aperta Ell. & Sol.

¹ Fossils identified by Dr. W. H. Dall.

Nucula aff. *ovula* Lea.
Ostrea sellæformis Conrad?
Lucina.
Venericardia.
Calyptraea aperta Ell. & Sol.
Leda.
Nucula.
Modiola.
Corbula alabamiensis Lea.
Numerous sharks' teeth, plates of the carapace of a turtle.

Locality. — Wren's Mill, 2 miles south of Wren's station, Jefferson county.

Ostrea, not positively determinable, probably young or small specimen of *O. georgiana* Conrad.

Locality. — Three miles northwest of Louisville, on the road to Clark's Mill, Jefferson county.

Scutella or *Clypeaster*.
Mesalia vetusta Conrad.

Locality. — Near Cowart's bridge, Ogeechee River, 2½ miles southeast of Louisville, Jefferson county.

Ostrea georgiana Conrad.

Locality. — L. R. Farmer's property, Bostick Mill Creek, 3½ miles southwest of Louisville, Jefferson county.

Turritella carinata Lea.
Cytherea perovata Conrad.

Locality. — Bethel Church, 4½ miles southwest of Louisville, Jefferson county.

Turritella carinata Lea.
Mesalia vetusta Conrad.
Glycymeris n. sp.
Cytherea perovata Conrad.
Spisula probably *praetenuis* Conrad.

Locality. — Old Town, $7\frac{1}{2}$ miles southwest of Louisville, Jefferson county.

Olivella sp.
Turritella *carinata* Lea.
Glycymeris *staminea* Conrad.
Glycymeris n. sp.
Diplodonta *ungulina* Conrad.
Lucina aff. *pandata* Conrad.
Venericardia *alticostata* Conrad.
Cytherea *perovata* Conrad.
Spisula *praetenuis* Conrad.

Locality. — The Buhrstone Quarry, 8 miles southeast of Louisville, Jefferson county.

Turritella *carinata* Lea.
Mesalia *vetusta* Conrad.
Corbula *densata* Conrad.

Locality. — Central of Georgia Railroad well, 30 ft. below the surface, Wadley, Jefferson county.

Flabellum *cuneiforme* Lonsdale.
Platytrochus *stokesi* Lea.
Endopachys *maclurei* Lea.
Mesalia *vetusta* Conrad.
Calyptrea *aperta* Solander.
Nuculus *ovula* Lea.
Leda *multilineata* Conrad.
Meretrix *perovata* Conrad?
Venericardia *alticostata* Conrad.
Corbula *densata* Conrad.
Lunulites sp., very large species.

Locality. — Wadley-Mount Vernon Railroad bridge, William's Swamp Creek, Jefferson county.

Scutella sp.
Turritella sp.
Cytherea sp.

Locality. — The Wadley-Midville public road, 6½ miles from Wadley, Burke county.

Turritella carinata Lea.

Pecten

Cytherea perovata Conrad.

Locality. — Railroad cut two miles southwest of Chalker, Washington county.

Flabellum cuneiforme Lonsdale.

Cucullæarca cuculoides Conrad.

Cerithium 2 sp.,; both apparently new.

Turritella carinata Lea.

Mesalia vetusta Conrad.

Ostrea georgiana Conrad?

Venericardia.

Cytherea.

Corbula alabamiensis Lea.

Locality. — T. W. Smith's farm, 2¼ miles south of Warthen, Washington county.

Scutella or *Clypeaster*.

Mesalia vetusta Conrad.

Calyptraea aperta Ell. & Sol.

Cerithium, probably new.

Glycymeris trigonella Conrad.

Glycymeris staminea Conrad? Young.

Lucina alveata Conrad.

Lucina papyracea Lea.

Lucina sp.

Corbula alabamiensis Lea.

Cytherea discoidalis Conrad.

Macoma or *Metis* sp.

Crassatellites protexta var. *lepida* Dall.

Solen or *Tagelus* sp.

Locality. — Clifton Shepherd's plantation, on the Sparta-Sandersville road, $3\frac{1}{2}$ miles northwest of Warthen, Washington county.

Flabellum sp.

Turritella carinata Lea.

Locality. — Ben Rollins Well, $\frac{3}{4}$ miles southwest of the court house, Sandersville, Washington county.

Scutella, the same species as the one found at the other localities.

Mesalia vetusta Conrad.

Nucula sp.

Ostrea, probably *georgiana* Conrad.

Panopaea.

Locality. — Lime Sink, 1 mile southwest of the court house, Sandersville, Washington county.

Scutella sp., the same as the species listed above, and the same as the one found at W. T. Smith's farm, $2\frac{1}{2}$ miles southeast of Warthen.

Locality. — Spring, 1 mile south of Sandersville, Washington county.

Ostrea georgiana Con. var.

Locality. — North Branch of Limestone Creek, 2 miles south of Sandersville, Washington county.

Scutella sp., the same as the one at T. W. Smith's farm, &c.

Ostrea georgiana Conrad.

Locality. — Roadside from Limestone church, 4 miles west of Sandersville, Washington county.

Mesalia vetusta Conrad.

Nucula cf. *ovula* Lea.

Leda.

Pecten wahtubbeanus Dall.
Diplodonta (*Sphaerella*).
Corbula cf. *oniscus* Conrad.
Corbula cf. *densata* Conrad.

Locality. — The big gullies, on the Upper Milledgeville public road, 5½ miles northwest of Sandersville, Washington county.
A species of the Volutidæ, new genus and new species — previously collected by Mr. McCallie.

Locality. — Old lime kiln, ¼ mile west of depot, Sun Hill, Washington county.
Flabellum cuneiforme Lonsdale.
Pecten cf. *wahtubbeanus* Dall.
Venericardia alticostata Conrad.
Crassatellites cf. *protexta* var. *lepida* Dall.

Locality. — Cut on the Central of Georgia Railroad between mileposts 138 and 139, Washington county.
Endopachys maclurei Lea.
Scutella sp., the common Eocene species of eastern Georgia.
Glycymeris staminea.
Glycymeris trigonella Conrad.
Ostrea alabamiensis Lea.
Crassatellites protexta var. *lepida* Dall.
Crassatellites alta Conrad.
Corbula alabamiensis Lea?
Corbula oniscus Conrad?

Locality. — P. L. Fair's well, near Poplar church, 13½ miles west of Sandersville, Washington county.
Nucula ovula Lea.
Glycymeris trigonella Conrad.
Ostrea alabamiensis Lea.
Modiolus aff. *texanus* Gabb.

Locality. — Cut on the Georgia Railroad, at Central of Georgia Railroad crossing, $1\frac{1}{4}$ miles east of Roberts station, Jones county.

- Cylichna sp.
- Volutilithes petrosus Conrad.
- Clavelithes sp.
- Turritella apita de Gregorio.
- Turritella sp.
- Natica semilunata Lea.
- Calyptrea aperta Sol.
- Adeorbis n. sp.?
- Nucula ovula Lea.
- Yoldia aff. psammotaea Dall.
- Leda aff. albirupiana Harris.
- Leda parva Rogers.
- Trigonarca pulchra Gabb.
- Glycymeris trigonella Conrad.
- Pecten (Pseudamusium) aff. dalli Clark, the Georgia specimen is slightly more acute than those from Miss., Va. and Md.
- Modiolus alabamiensis Aldrich.
- Psammobia — apparently 2 sp., P. blainvillei.
- Lea and Psammobia (Gobraeus) papyria Conrad, however the specimens are too poor for positive identification.
- Lucina papyracea Lea.
- Lucina cf. pandata Conrad.
- Venericardia, young, probably several species.
- Cytherea aequorea Conrad? juv.
- Corbula oniscus Conrad.
- Corbula alabamiensis Lea.

Locality. — The Gordon-Macon public road, 2 miles west of Gordon, Wilkinson county.

- Platytrochus stokesi Lea.
- Volutilithes petrosus Conrad.
- Nucula ovula Lea.
- Leda bella.

Leda coelata Conrad?
Leda sp.
Tagelus sp.
Diplodonta (*Sphaerella*) aff. *inflata* Lea.
Lucina aff. *claibornensis* Conrad.
Cytherea sp.

Locality. — J. W. Huckabee's farm, 1½ miles west of Lewistown,
Jones county.

Endopachys Maclurei Lea.
Turbinella sp.
Turritella carinata Lea.
Mesalia vetusta Conrad.
Nucula ovula Lea.
Glycymeris aff. *staminea* Conrad.
Lucina cf. *pandata* Conrad.
Venericardia planicosta Lam.
Crassatellites protexta Conrad.
Corbula oniscus Conrad.
Corbula alabamiensis Lea.

Locality. — J. R. Van Buren and Company's property, 1½ miles
west of Griswoldville, Jones county.

Platytrochus stokesi Lea.
Flabellum cuneiforme wailesi Conrad.
Endopachys maclurei Lea.
Turbinolia pharetra Lea.
Turbinella sp.
Volutilithes sayanus Conrad?
Levifusus trabeatus Conrad.
Mesalia vetusta Conrad.
Calyptraea aperta Solander.
Dentalium aff. *blandum* de Greg.
Nucula ovula Lea.
Nucula magnifica Lea.
Lucina carinifera Conrad.

Protocardia sp.
Crassatellites protexta Conrad.
Corbula alabamiensis.
Corbula oniscus Conrad?
Panopaea sp.

Locality. — Gallemore station, Twiggs county.

Volutilithes petrosus Conrad.
Calyptraea aperta Solander.
Turritella carinata Lea.
Mesalia vetusta Conrad.
Leda sp.
Glycymeris sp.
Diplodonta unguina Conrad?
Lucina alveata Conrad.
Corbula sp.

Locality.—H. W. McCrary's farm, 2 miles north of Jeffersonville,
on the Jeffersonville-Irwinton public road, Twiggs county.

Turbinella (Psilocochlis) mcalliei Dall.
Buccinanops altile Conrad.
Muricidea sp. nov.
Cerithium sp. nov.
Mesalia vetusta Conrad.
Nucula.
Cytherea discoidalis Conrad.
Cytherea sp.
Venericardia planicosta Lam.
Corbula alabamiensis Lea.

Locality. — The Carlton Clay Works, $\frac{3}{4}$ mile west of Pike's Peak,
Twigg's county.

Nucula aff. ovula Lea.
Ostrea georgiana Conrad.
Crassatellites protexta Conrad.

Locality. — Brown's Mountain, 9 miles southeast of Macon, Bibb county.

Flabellum cuneiforme Lonsdale.

Endopachy maclurei Lea.

Scutella.

Calyptrophorous velatus Conrad.

Turritella carinata Lea.

Mesalia vetusta Conrad.

Calyptrea aperta Sol.

Nucula ovula Lea.

Pteria.

Pecten wahtubbeanus Dall.

Venericardia

Lucina carinifera Con.

Cytherea — 2 sp.

Protocardia sp.

Crassatellites protexta Con.

Panapæa.

Corbula oniscus Con.

Corbula densata Conrad?

Locality. — Macon-Marion public road, 9 miles southeast of Macon, Bibb county.

Scutella sp., the same as the one found at Lime Kiln, 1 mile east of Bond P. O.

Levifusus trabeatus Conrad.

Locality. — Macon-Marion public road, 10 miles south of Macon, Twiggs county.

Nucula ovula Lea.

Diplodonta sp.

Crassatellites protexta Conrad.

Several species of fossil leaves, but as they have not been studied, they at present furnish no information of value in determining the horizon.

Locality. — Perry-Elko public road, 4 miles south of Perry, Houston county.

Turbinolia pharetra Lea.
Flabellum cuneiforme Lonsdale.
Volutilithes petrosus Conrad.
Levifusus trabeatus Conrad.
Turritella carinata Lea.
Mesalia vetusta Conrad.
Calyptraea aperta Solander.
Dentalium thalloides Conrad.
Nucula ovula Lea.
Leda n. sp.?
Glycymeris trigonella Conrad.
Glycymeris sp.
Pteria sp.
Lucina alveata Conrad.
Lucina aff. *claibornensis* Conrad.
Venericardia planicosta Lam.
Venericardia alticostata Conrad.
Cytherea sp.
Crassatellites protexta Conrad.
Corbula oniscus Conrad.
Pteropsis lapidosa Conrad.

VICKSBURG-JACKSON HORIZON.

Locality. — Bluff, Ring Jaw Landing, Oconee River, 2 miles west of Kittrell's, Johnson county.

Orbitoides sp.
Flabellum cuneiforme Lonsdale.
Platytrochus stokesi Lea.
Endopachys maclurei Lea.
Scutella or *Clypeaster*.
Nucula ovula Lea.
Leda.
Pecten fragment, *nuperus* Conrad or *perplanus* Morton.
Ostrea trigonalis Conrad.

Lunulites — large species.
Pleurotoma.
Volutilithes.
Glycymeris.
Corbula.
Cytherea.
Tagelus?

Locality. — Magnolia Spring, 5 miles north of Millen, Burke county.

Pecten sp., probably an undescribed species.

Locality. — Martain's Mill, Battle Field Branch, 1 mile north of Kite, Johnson county.

Ostrea georgiana Conrad.

Locality. — Pumping Station, City Water-Works, Dublin, Laurens county.

Turritella sp.

Glycymeris cf. arcata Conrad.

Pecten cf. poulsoni Morton.

Locality. — "Well Spring," Oconee River, 9 miles southeast of Dublin, Laurens county.

Orbitoides? casts.

Pecten poulsoni Morton.

Locality. — The McRea farm, 3 miles east of Westlake, Twiggs county.

Scutella.

Pecten perplanus Morton.

Amusium ocalanum Dall.

Locality. — Macon-Cochran public road, Twiggs county, one mile east of Westlake.

Platytrochus stokesi Lea.

Endopachys maclurei Lea.
Nucula ovula Lea.
Venericardia.
Lucina.
Panopaea, &c.

Locality. — Macon-Cochran public road, on Shell Creek, near Westlake, Twiggs county.
Pecten perplanus Morton.

Locality. — Lime Kiln, 1 mile east of Bond P. O., Bibb county.
Endopachys sp.
Scutella sp., the same as at locality 2 miles south of Perry.
Pecten nuperus Conrad.
Cytherea sp.
A foliaceous bryozoan.

Locality. — Harry Wimberly's farm, 9 miles northeast of Cochran, on Macon-Cochran public road, Pulaski county.
Cassidulus.
Clypeaster or *Scutella*.
Turritella mississippiensis Conrad?

Locality. — Public road, near the water tank, Southern Railway, 1 mile northeast of Coley, Pulaski county.
Cassidulus.
Clypeaster.
Pecten.

Locality. — Right bank of Ocmulgee River just below the wagon bridge, Hawkinsville, Pulaski county.
Orbitoides.
Clypeaster.

Locality. — Railroad cut, near the depot, Hawkinsville, Pulaski county.
Orbitoides.
Cytherea sobrina Conrad.

Locality. — Railroad cut, $\frac{1}{4}$ mile north of Bonaire, Houston county.

Scutella sp.

Caricella sp.

Turritella sp.

Pecten perplanus Morton.

Cytherea, at least 2 sp.

Basilosaurus sp., probably *B. macrospondylus* Harlan.

Locality. — Public road two miles south of Perry, Houston county.

Orbitoides mantelli Morton.

Orbitoides papyracea Boubée.

Scutella sp.

Pecten perplanus Morton.

Locality. — Perry-Elko public road, $3\frac{1}{4}$ miles southeast of Perry,
Houston county.

Volutilithes petrosus Conrad.

Fusoficula cf. *filia* Meyer.

Turritella sp.

Calyptraea alta Conrad.

Calyptraea aperta Solander.

Dentalium thalloides Conrad.

Nucula ovula Lea.

Leda multilineata Conrad.

Leda sp.

Glycymeris sp.

Pecten cf. *nuperus* Conrad.

Cytherea 2 sp.

Venericardia cf. *rotunda* Lea.

Spisula cf. *funerata* Conrad.

Corbula wailesiana Harris.

Lunulites sp.

Pecten perplanus Morton.

Numerous bryozoa.

Locality. — Big Creek, Elko-Unadilla road, 1½ miles south of Elko, Houston county.

Orbitoides papyracea Boubée.

Conus sp.

Pecten perplanus Morton.

Cytherea sobrina Conrad.

Locality. — Taylor's church, Elko-Unadilla road, 4 miles south of Elko, Houston county.

Orbitoides sp.

Cerithiopsis sp.

Turritella sp.

Glycymeris n. sp., aff. *arctata* Conrad.

Glycymeris n. sp.?

Pecten nuperus Conrad.

Cytherea sobrina Conrad.

Pitaria sp., *imitabilis* Conrad? Young.

Chione.

Lucina sp.

Crassatellites mississippiensis, Conrad.

Locality. — Perry-Henderson public road, 5¼ miles south of Perry, Houston county.

Flabellum cuneiforme Lonsdale.

Endopachys sp.

Turritella.

Leda multilineata Conrad.

Leda, very large species, cf. *pharcida*, Dall, but apparently new.

Lucina sp. also found in the clay bed at Rich Hill.

Protocardia nicoletti Conrad.

Corbula, apparently *wailesiana* Harris.

Locality. — Rich Hill, Crawford county.

Scutella.

Ostrea georgiana Conrad.

Ostrea sp.

Pecten perplanus Morton.
Bryozoa, not determined, many species.
Volutilithes.
Calyptra aperta Solander.
Venericardia.
Lucina, found also $5\frac{1}{4}$ miles south of Perry.
Panopaea.

Locality. — Brook's farm, 12 miles southwest of Marshallville, Macon county.

Scutella sp.

Pecten — apparently fragments of *P. perplanus* Morton.

Bryozoa numerous.

Locality. — Three miles east of Marshallville, Houston county.

Scutella sp., the same as the species found at Rich Hill.

Bryozoa, numerous.

Locality. — Cooper farm, just east of Hogcraw Creek, 13 miles southeast of Marshallville, Macon county.

Glycymeris cf. *arctatus* Conrad.

Pecten perplanus Morton.

Locality. — Rock dam on Hogcraw Creek, 8 miles east of Montezuma, Macon county.

Lyria costata Sowerby.

Turritella sp.

Glycymeris sp.

Cytherea sobrina Conrad.

Protocardia, large sp.

Locality. — Three miles west of Coney, at Seaboard Air Line Railroad bridge.

Orbitoides.

Pecten perplanus Morton.

Locality. — U. S. Lockett's farm on Seaboard Air Line Railroad,
2½ miles southeast of Americus, Sumter county.

Orbitoides.

Glycymeris cf. arctatus Conrad.

Locality. — C. H. Spring's farm on the Isabella-Albany public road,
5½ miles west of Isabella, Worth county.

Orbitoides and probably Nummulites.

Turbinella wilsoni Conrad?

Locality. — Rock Pond, 1½ miles north of Camilla, Mitchell county.

Glycymeris sp.

Pecten 2 sp.

Locality. — Preston-Friendship public road, 6 miles northeast of
Preston, Webster county.

Orbitoides.

Clavelithes, Vicksburg species.

Pecten poulsoni Morton?

Locality. — Richland-Weston public road, near Mt. Zion church,
about 3 miles northwest of Weston, Webster county.

Pecten perplanus.

Locality. — Black farm on the Weston-Preston public road, 1 mile
northeast of Weston, Webster county.

Orbitoides, very abundant.

Pecten perplanus Morton.

Cytherea sobrina Conrad.

Locality. — J. W. Tilley's farm, on Weston-Parrott public road, 4
miles north of Parrott, Webster county.

Orbitoides, very abundant.

Locality. — Parrott-Dawson public road, one mile south of Parrott.

Orbitoides.

Casts of several species of mollusks.

Locality. — Cut on Central of Georgia Railroad, at Dawson, Terrell county.

Cassidulus sp.

Glycymeris arctata Conrad?

Pecten perplanus Morton.

Crassatellites sp.

Locality. — On Fowltown Creek, 1 mile north of Armena, Terrell county.

Orbitoides, very abundant.

Locality. — Cuthbert-Lumpkin public road, 2½ miles north of Cuthbert.

Cassidulus sp.

Pecten perplanus Morton.

Locality. — Elder's Quarry, 1 mile west of Cuthbert, Randolph county.

Cytherea sobrina Conrad?

Arca mississippiensis Conrad?

Locality. — Martin Harrell's farm, 11 miles north of Whigham.

Orbitoides.

Pecten.

Locality. — Rock Pond, 11 miles north of Whigham, Decatur county.

Glycymeris.

Ostrea.

Pecten, &c.

Bill of a duck-like bird.

Locality. — Jas. Hornsby's property, 1 mile northeast of Whigham and ¾ mile north of railroad.

Orbitoides papyracea Boubeé.

Locality. — One mile northwest of Faceville, Decatur county.
Operculina.
Nummulites.

Locality. — L. A. Baron's farm, 4 miles northeast of Forest Fall,
Decatur county.
Orbitoides and other foraminifera.

Locality. — Dan Morris's well, 3 miles north of Forest Falls, 16th
district, Decatur county.
Orbitoides.
Pecten perplanus Morton.

Locality. — Twelve miles north of Bainbridge and 3 miles west of
Flint River, near E. B. Jones' residence.
Ormitoides.
Cassidulus.
Clypeaster.
Amusium ocalanum Dall.
Spondylus dumosus Morton.
Crassatellites, &c.

Locality.¹ — Forest Falls, 7 miles north of Whigham, Decatur
county.
Cardium.
Pecten.

Locality. — Bluff on the Flint river about 8 miles below Bainbridge,
Decatur county.
Aturia.
Echini.
Turritella.

¹ According to Dr. Dall's interpretation of the fossils collected by the writer at Forest Falls, the upper part of the section belongs to the Tampa siliceous bed, and the lower part to the Peninsular limestone.

Locality. — Blue Hole, 8 miles northeast of Bainbridge, Decatur county.

Cerithium.

Diplodonta.

Mitra.

Teredo.

Cardium.

Glycymeris.

Locality.¹ — Boston Phosphate Works, Thomas county.

Teredo, etc.

Locality.¹ — McIntyre's plantation, 11 miles south of Thomasville, Thomas county.

Turritella indenta Conrad.

Coral (*Orbicella*).

Locality.¹ — New bridge, the Withlacoochee River, on the Valdosta-Madison public road, 15 miles south of Valdosta, Lowndes county.

Orbicella.

Pyraxisinus sp.

Turritella.

Locality.¹ — Banks of the Allapaha River, Statenville, Echols county.

Orbitoides.

Echini.

Locality.¹ — Prescott plantation, Allapaha River at the Georgia-Florida line, Echols county.

Helix.

Locality. — Camp Perry, Florida, at the end of the Coast Line Railroad bridge.

Rangia sp.

Orbitoides.

¹ The fossils from these localities seem to point to the Peninsular or the Ocala limestones, which limestones are often overlain by sandy clays belonging to the Chattahoochee horizon.

[MIOCENE HORIZON (INCLUDING UPPER OLIGOCENE)

Locality.¹ — The Sink of the Level, 10 miles north of Whigham,
Decatur county.

Pecten.

Locality.¹ — Old Phosphate Works, 3 miles west of Boston, Thomas
county.

Coral.

Locality.¹ — McIntyre's plantation, 11 miles south of Thomasville,
Thomas county.

Coral.

Locality.¹ — Boston-Monticello public road, 4½ miles south of Bos-
ton, Thomas county.

Siderastrea.

Ostrea.

Locality.¹ — J. C. Burrow's place, 4 miles northeast of Forest Falls,
Decatur county.

Siderastrea.

Ostrea.

Locality.¹ — New Graveyard, 1½ miles east of Quitman, Brook
county.

Siderastrea.

Locality.¹ — Lucas T. Lane's property, 2 miles northeast of Clyatts-
ville, Lowndes county.

Siderastrea.

¹ Chattahoochee horizon here, consisting of sandy clays, is underlain by the Peninsular or the Ocala limestones.

Locality.¹ — New bridge on the Valdosta-Madison public road, 15 miles south of Valdosta, Lowndes county.
Siderastrea.

Locality.² — College Creek, Livingston plantation, 18 miles west of Brunswick, Glynn county.
Pecten sp. Too poor for determination.

Locality. — Well at Brunswick, 50-62 feet.
Glycymeris, fragment of large species.
Pecten madisonius Say.
Astarte undulata Say.
Chione athleta Conrad.
Venericardia.

Locality. — Bluff on Altamaha River, about 2 miles above Doctortown, Wayne county.
Pecten eboreus Conrad.

Locality. — Bluff on the Altamaha River at Doctortown, Wayne county.
Pecten eboreus.

Locality. — Porters landing on the Savannah River, Effingham county.
Pecten eboreus.

¹ Chattahoochee horizon here, consisting of sandy clays, is underlain by the Peninsular or the Ocala limestones

² It seems to be more than likely that this locality is Pliocene.

PLIOCENE HORIZON.

Locality. — Waverly, Camden county.
Charcardon megalodon Agassiz.
Cetacean vertebra.
Equus complicatus Leidy.

Locality. — James King's plantation, on Big Satilla River, 5 miles
south of Atkinson, Wayne county.
Rangia cuneata Gray.



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